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SAFETY CLIMATE ASSESSMENT IN NAVAL RESERVE AVIATION MAINTENANCE OPERATIONS

by

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September 1999

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Naval Aviation's annual Class 'A' Flight Mishap rate is commonly used as a measure of safety effectiveness. Interventions implemented over the past four decades greatly reduced mishap occurrence by focusing on aircrew and supervisory error. Less attention has been paid to the role maintenance plays in Naval Aviation mishaps, though it is consistently responsible for approximately 16 percent of all Class 'A' Flight Mishaps. In 1998, a Maintenance Climate Assessment Survey (MCAS) was developed to evaluate safety concerns from the perspective of an aircraft maintainer. This thesis utilized the revised MCAS to assess its validity and utility as a diagnostic tool to access several aircraft communities within the Naval Reserve. It proved useful in aiding Commanders and Aviation Safety Officers (ASOs) in evaluating their maintenance operation's safety posture. The results of this study produced a finalized MCAS for fleet wide distribution. The findings will serve to encourage proactiveness within aviation maintenance in the areas of safety awareness and risk management. This tool will also aid the monitoring of ongoing safety programs or implementation of new ones.

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SAFETY CLIMATE ASSESSMENT IN NAVAL RESERVE AVIATION MAINTENANCE OPERATIONS

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ABSTRACT

Naval Aviation's annual Class 'A' Flight Mishap rate is commonly used as a measure of safety effectiveness. Interventions implemented over the past four decades greatly reduced mishap occurrence by focusing on aircrew and supervisory error. Less attention has been paid to the role maintenance plays in Naval Aviation mishaps, though it is consistently responsible for approximately 16 percent of all Class 'A' Flight Mishaps. In 1998, a Maintenance Climate Assessment Survey (MCAS) was developed to evaluate safety concerns from the perspective of an aircraft maintainer. This thesis utilized the revised MCAS to assess its validity and utility as a diagnostic tool to access several aircraft communities within the Naval Reserve. It proved useful in aiding Commanders and Aviation Safety Officers (ASOs) in evaluating their maintenance operation's safety posture. The results of this study produced a finalized MCAS for fleet-wide distribution. The findings will serve to encourage proactivity within aviation maintenance in the areas of safety awareness and risk management. This tool will also aid the monitoring of ongoing safety programs or implementation of new ones.

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EXECUTIVE SUMMARY

Naval Aviation has done a remarkable job cutting its mishap rate in half each decade between the 1950s and 1990s. Vast improvements in aircraft technology, coupled with a high degree of standardization have reduced the role that mechanical failures play in aircraft mishaps to an all time low. Standardization and aggressive training has also reduced the role that human error plays in mishaps. Despite the overall decrease, human error related causal factors seem to have leveled off, and in recent years are even increasing. In recent years, a Human Factors Quality Management Board (HFQMB) has had much success by focusing on evaluating the contribution aircrew error plays in Class 'A' mishaps.

The initial progress achieved by the HFQMB was impressive. In 1997, Naval Aviation experienced its second lowest Class 'A' mishap rate of all time, with the Navy recording its all time low. It achieved this by applying the practices and procedures obtained through the study of high-risk organizations (HROs); organizations that though operating in high-reliability environments sustained high rates of safety. This success prompted a look into reducing maintenance-related mishaps (MRMs) via the same approach of mishap data analysis, benchmarking, and climate safety assessment.

This thesis is an extension of the efforts to reduce MRMs by assessing the prevailing attitude toward safety held by those who actually perform aircraft maintenance. It entails the analysis of data obtained through the administration of a survey containing questions based on an existing Model of Organizational Safety Effectiveness (MOSE). The results of this thesis are intended to provide a better understanding into the possible human factors involvement in MRMs and furnish the

Squadron Commander and Aviation Safety Officer (ASO) with a tool for assessing the safety posture of their unit's maintenance operations.

The study encompassed 439 maintenance personnel across three different aircraft communities within a common Naval Air Reserve Force (NARF). The questionnaire consisted of 35 items, each rated according to a five-point Likert scale (strongly disagree, disagree, neutral, agree, strongly agree). The questions originated from each of the six MOSE categories: Process Auditing, Reward System, Quality Assurance, Risk Management, Command and Control, and Communication and Functional Relationships.

Basic data exploration and descriptive statistics were performed on the data set to determine its underlying distribution and summarize respondents' answers. Principal component analysis and clustering analysis were conducted to determine if the survey was dominated by any particular MOSE component(s). Analysis of variance (ANOVA), and multiple comparison testing were performed on the data to identify any commonality/differentiation among the various communities with respect to their prevailing attitude toward aviation safety in maintenance operations.

The results of this study show that a squadron's safety posture can be accurately assessed through the use of the MCAS. The analysis identifies no significant difference between each of the three communities surveyed with respect to their overall attitude toward safety during the conduct of aviation maintenance. Each community displays a positive outlook with respect to the way day-to-day maintenance operations are conducted.

Analysis also reveals that despite the overall favorable attitude, some areas of concern do exist. These concerns target perceptions of inappropriate staffing levels and

communication breakdowns that occur due to the overcommitting of limited personnel. These concerns can serve as starting points for the implementation of intervention strategies. By linking problem areas to their corresponding MOSE components, these interventions can be specifically tailored to achieve maximum applicability. This study concludes with the restructuring of the MCAS, which results in an increase from 35 to 40 questions. It is believed that the increase in survey size is outweighed by the benefit of clarity obtained by the restructuring.

By utilizing the MCAS, evaluation of a squadron's safety posture can be assessed on a continual basis. Problem areas can be identified and cross-referenced to specific MOSE components, which can aid Naval Aviation in the implementation of procedures that directly target threats to safety. An organization need not wait for a mishap to occur in order to make changes in its safety posture. For it is only through a proactive stance that Naval Aviation can achieve for a lower mishap rate in today's high paced operating environment.

LIST OF ACRONYMS

ACT	Aircrew Coordination Training
ALPA	Airline Pilot Association
ASO	Aviation Safety Officer
CSA	Command Safety Assessment
FAA	Federal Aviation Administration
FM	Flight Mishap
FRS	Fleet Replacement Squadron
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
HF	Human Factors
HFACS	Human Factors Accident Classification System
HFQMB	Human Factors Quality Management Board
HRO	High Reliability Organization
ILS	Instrument Landing System
JAL	Japan Air Lines
MCAS	Maintenance Climate Assessment Survey
MOSE	Model of Organizational Safety Effectiveness
MRM	Maintenance Related Mishap
NAMP	Naval Aviation Maintenance Procedures
NAS	Naval Air Station
NASA	National Aeronautics and Space Administration
NSC	Naval Safety Center
NATOPS	Naval Air Training and Operating Procedures Standardization
ORM	Operational Risk Management
PAT	Process Action Team
SELRES	Selected Reserve
TAR	Training and Administration of Reserves
TCAS	Traffic Collision Avoidance System

I. INTRODUCTION

Naval Aviation's current operational tempo, manning shortages, and lengthier deployments pose significant challenges to maintaining an aging fleet of aircraft. Present (and forecasted) declining retention rates will exacerbate this situation, impairing mission readiness and potentially fostering mishaps (Dake, 1998; Mann, 1998). Further, increased pressure to meet mission requirements can prompt personnel to compromise safety by taking shortcuts or skipping procedures, often resulting in disastrous situations (Perrow, 1984). The combination of these factors serve to alter an organization's culture and its perspective on safety posture (Pidgeon, 1991). This thesis focuses on the safety posture across differing aircraft communities within a common Naval Reserve Wing. It will attempt to determine if the aforementioned conditions pose a threat to the safety climate among the communities' maintenance operations. This study also parallels similar research being conducted by Goodrum (1999), that concentrates on the prevailing safety attitude among differing squadrons within a common community.

A. BACKGROUND

Naval Aviation has done a remarkable job cutting its mishap rate in half each decade between the 1950s and 1990s as depicted in Figure 1. Vast improvements in aircraft technology, coupled with a high degree of standardization has reduced the role that mechanical failures play in aircraft mishaps to an all time low as depicted in Figure 2. Standardization and aggressive training has also reduced the role that human error plays in mishaps. Figure 2 also reveals that despite the overall decrease, human error related causal factors seem to have leveled off, and in recent years are even increasing.

This relationship is possibly due to the current pressures imposed by a high state of operational tempo coupled with personnel downsizing and increased aircraft technical complexity (Rhame, 1999). This marked trend, and a sequence of events in 1996 caused Naval Aviation leadership to reevaluate the way it conducts business.

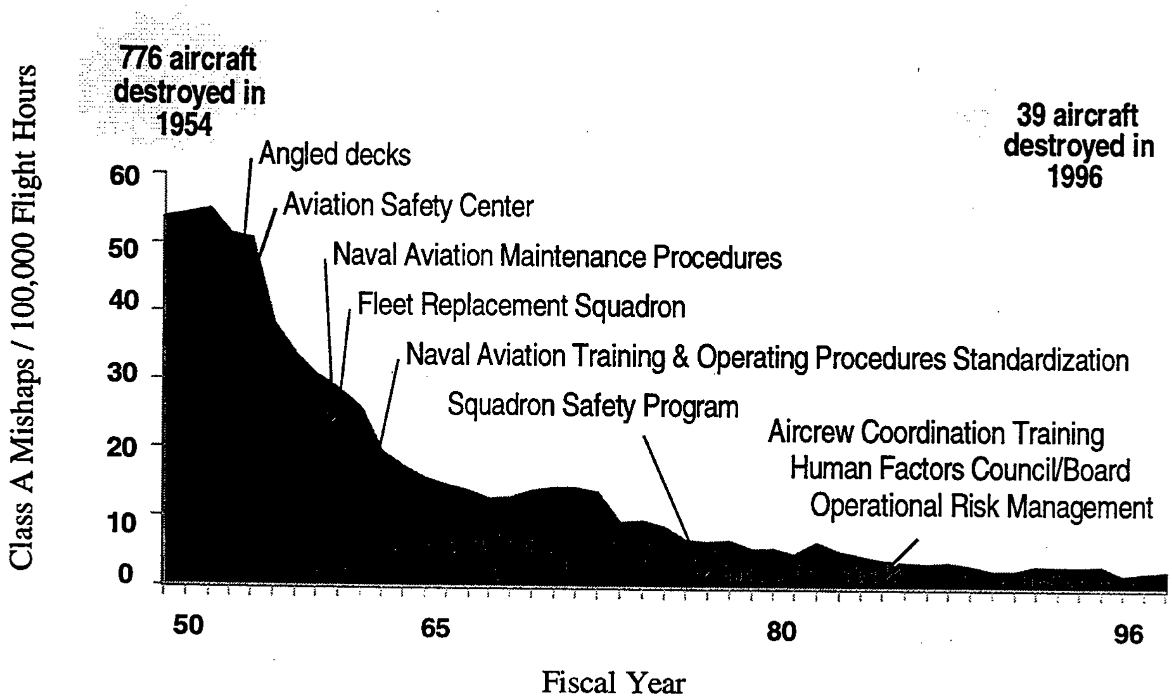

Figure 1. FY 90-96 Naval Aviation Flight Mishap Rates and Intervention Strategies. (Naval Safety Center, HFACS Brief, 1997).

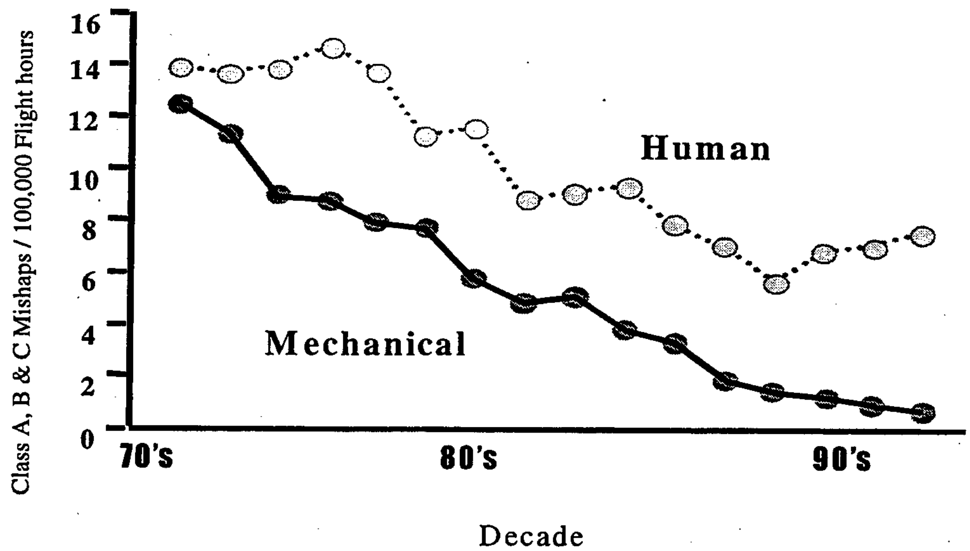

Figure 2. Mechanical Failures vs. Human Errors in Naval Aviation Mishaps. (Naval Safety Center, HFACS Brief, 1997).

In 1996, a string of 17 Class 'A' mishaps occurred within a 75 day period culminating with a Navy F-14 "Tomcat" crashing into a residential Nashville, TN neighborhood killing not only the aircrew, but some local residents as well (Nutwell & Sherman, 1997). Class 'A' mishaps are defined as Naval aircraft incidents resulting in death, permanent disability, or loss of over one million dollars (OPNAV 3750.6Q, 1989). Presently, it's accepted that at least 80 percent of all Class 'A' mishaps since 1990 list human error as a contributing causal factor. As a result, Vice Admiral Brent Bennett, then Commander Naval Air Forces Pacific, established the Human Factors Quality Management Board (HFQMB). The HFQMB's purpose was to analyze and improve the processes, programs and systems that impact human performance in Naval Aviation with a goal to cut the current mishap rate in half by the year 2000 (Nutwell & Sherman, 1997).

The HFQMB (Nutwell & Sherman, 1997) concentrates on three main areas: (1) Class 'A' Flight Mishaps, (2) Organizational Benchmarking, and (3) Command Safety Assessment (CSA). The objective of evaluating Naval Aviation Class 'A' Flight Mishaps is to analyze past human factor involvement. As depicted in Figure 3, this evaluation identifies supervisory and aircrew factors to be major contributors in Class 'A' Flight Mishaps. The HFQMB elected at this point to concentrate on these two factors during its early phases. The benchmarking effort examines programs influencing aircrew performance. Among the successful strategies examined in similar organizations were Operational Risk Management (U.S. Army) and Line Oriented Flight Training (United Airlines). Many of these programs were selected for immediate consideration by the HFQMB for adoption and implementation given tailoring, resources and support.

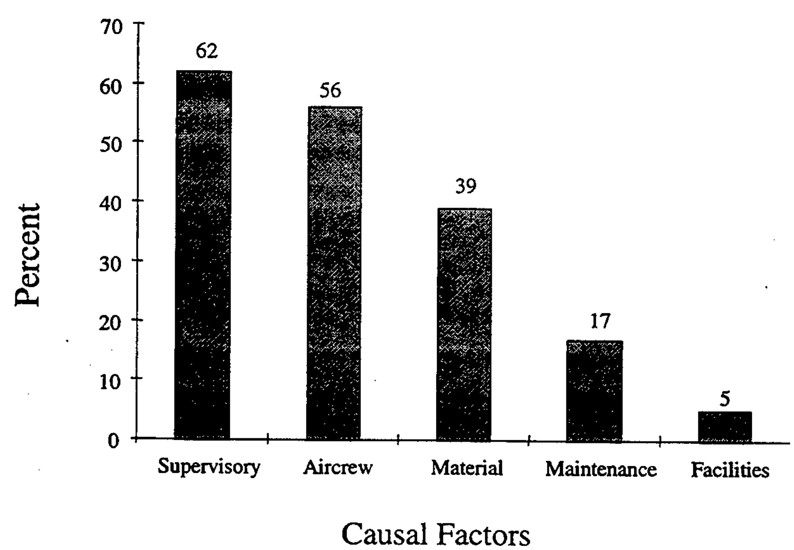

Figure 3. FY 90-96 Naval Aviation Class A Flight Mishap Causal Factors. (Naval Safety Center, HFACS Brief, 1997).

The CSA survey as a climate evaluation instrument determines a command's safety posture from an aircrew perspective, which was based on the level of involvement of aircrew caused mishaps (Civarelli & Figlock, 1996). The CSA survey is based on a model of High Reliability Organizations (HROs) and consists of five basic components: Process Auditing (PA), Reward System (RS), Quality Assurance (QA), Risk Management (RM) and Command and Control (CC). The CSA, in a survey of 67 squadrons, effectively uncover deficiencies and strengths in Naval Aviation (Nutwell & Sherman, 1997). For example, it showes significant room for improvement in the areas of risk management, human factors evaluation, and aircrew coordination training. This survey is now a tool being provided to all Commanding Officers and Aviation Safety Officers (ASOs) for self-assessment of their command's flight operations safety posture (R. Figlock, personal communication, 1999).

The approach taken by the HFQMB has shown merit; in 1997 the U.S. Navy experiences its lowest Class 'A' Flight Mishap rate, and Naval Aviation as a whole has its second lowest rate. In 1998, the U.S. Marine Corps has its lowest Class 'A' Flight Mishap rate as a service. Despite this success, the HFQMB is still far from achieving its stated goal of a 50 percent reduction in human error mishaps. This necessitates a shift to impact areas in addition to supervisory and aircrew error. The HFQMB forms a Human Factors Maintenance Process Action Team (PAT). The PAT develops a charter similar to that of the HFQMB while developing its three pronged approach of Mishap Data Analysis, Benchmarking, and Command Safety Assessment.

To date, there has been markedly less interest concerning the impact of human factors on military aviation maintenance operations. The primary reason being that

maintenance related mishaps (MRMs) generally account for only 15-17 percent of the Class 'A' Flight Mishaps. However, though maintenance is involved in a small number of Class A's, it is involved in a relatively large number of Class C's. Very little has been published about human factor involvement in Naval Aviation maintenance at either the organizational or individual worker level. Indeed, a search of published references from 1976-1988 resulted in only 15 papers on the subject. This lack of interest was also shared by the commercial airline industry (Anonymous, 1999).

In the 1990s the Federal Aviation Administration (FAA) initiated a large-scale campaign to combat human factors in maintenance and inspection (FAA website). Their efforts to date have focused on the identification of maintenance error factors and strategies for their reduction, similar to the mishap data analysis and benchmarking thrust of the HFQMB. The only area that was not touched upon at that time was the safety climate and its assessment.

Noting this void, Baker (1998), in conjunction with Naval Postgraduate School (NPS) staff and Commander Naval Air Forces Pacific (CNAP) personnel, develops a maintenance version of the CSA that assesses the human factor involvement in aircraft maintenance from the perspective of the maintainers themselves. The Maintenance Climate Assessment Survey (MCAS) is administered to various Navy Reserve squadrons in California. Baker's goal is to gain a stronger understanding of the HRO factors within the reserve Naval Aviation maintenance community that contributed to safety / risk management.

B. PURPOSE

The purpose of this study is to administer and evaluate a questionnaire survey in an attempt to gain a broader understanding of the HRO factors within Naval Aviation across different aircraft communities. This study utilizes a revised survey developed by Baker (1998) as part of a HFQMB sponsored effort. This 35-item survey (reduced from an original prototype of 67 items) is the end result of Baker's NPS Master's Thesis Research. Results from this survey will be utilized to improve our understanding of possible influences that human factors play in aviation maintenance operations. Additionally, the results of the survey will provide the basis for assessing a Squadron's posture toward safe maintenance practices, with the intent of identifying potential areas for intervention.

C. PROBLEM STATEMENT

Human error in aviation maintenance, however small a role it plays in Class 'A' Flight Mishaps, requires that its contribution in the causal chain of events be understood. Through administration of the MCAS, an attempt will be made to gain insight to a Squadron's overall posture toward safety and safe maintenance practices in accordance with the model developed out of the evaluation of high-risk organizations. This thesis will explore the following questions:

1. Does the MCAS capture an overall attitude toward aviation maintenance safety from the maintainer's perspective?

2. Are there any discernable differences between squadrons / communities surveyed and / or does there appear to be any consensus?

3. Can the MCAS be refined further to either reduce its size or clarify any questions?

D. SCOPE AND LIMITATIONS

The intent of this study is to gain a better understanding of the maintainer's perspective on safety within Naval Aviation maintenance organizations. Select communities of the Naval Air Reserve Force (NARF) are surveyed due to the interest of the Commander, NARF, and the desire to assess the safety attitude across homogeneous populations. The only responses used in this analysis are those of Naval Aviation maintenance personnel. Incomplete surveys are omitted.

The next chapter will provide a literature review of the history of safety practices in civil and military aviation. Additionally, the concept of high-reliability organizations and the safety concepts employed by them will also be discussed. Methodology is discussed in Chapter III. Results of the study will be covered in Chapter IV, followed by conclusions and recommendations in Chapter V. Appendices provide supplemental information to augment material found throughout the body of the thesis.

II. LITERATURE REVIEW

An in depth literature review is conducted during the compilation of this thesis. It will begin with an overview of the importance of safety among aviation and high-reliability organizations. Next, a history of safety awareness in both civilian and military aviation is covered. The chapter finishes by discussing high-reliability organizations and the concept of corporate safety culture.

A. OVERVIEW

Naval Aviation is by its very nature a dynamic organization. But the nature of its being instills in it an inherent amount of danger. Indeed, the combined costs of all United States Navy (USN) and United States Marine Corps (USMC) mishaps was over four billion-dollars for fiscal years (FY) 1993-1998. Of this, aviation mishaps account for 3.8 billion dollars (95 percent) of the total cost. For Fiscal Year (FY) 1998, aviation mishaps account for 89 percent of total USN mishap costs and 93 percent of all USMC mishap costs. (Naval Safety Center, 1998).

Perrow (1984) states that high-risk organizations (HROs) are those which embody special characteristics beyond their normal dangers that make accidents in them inevitable, even normal; e g., nuclear power plants and petro-chemical plants. Naval Aviation (as with aviation in general) is considered to be a HRO (Figlock, 1998). Often these organizations are heavily regulated, and are required by law to adhere to strict safety guidelines (Eiff & Mattson, 1998). This in part accounts for the reason these HROs are able to operate in a relatively safe manner. However, there is another factor that impacts the success of these organizations; and that is the degree to which each HRO incorporates a cultural attitude toward safety. The term culture is defined as a collection

of norms, beliefs, roles, attitudes, and practices of a given group or organization (Turner, 1991). Naval Aviation can strive to achieve higher levels of safety than it currently enjoys by studying these "culturally safe" organizations and implementing their methods.

Safety is important to Naval Aviation for mishaps are costly and have an adverse effect on combat readiness. In addition, the Naval Safety Center (NSC) estimates that over the past decade the average cost per Class A mishap has quadrupled from $5.1 million to over $20 million per mishap (NSC, 1997). In addition, the USN and USMC accept delivery of only 40 new aircraft in FY-97 while losing 24 to mishaps (NSC, 1998). Since a number of aircraft are struck from the inventory each year due to age, we are hard pressed to keep par with aircraft requirements. With Department of Defense budgetary constraints/cutbacks that no longer permit the military to purchase as many aircraft as it once did, lost aircraft pose a void that cannot be easily filled (Figlock, 1998).

Personnel are also affected by mishaps. The most damaging effect of a mishap on personnel is the loss or impairment to human life. Whether permanent or temporary, this mishap result has a psychological effect that serves to further reduce a unit's effectiveness and morale. In addition, mishaps impact productivity. Productivity is reduced from either the temporary or permanent loss of personnel directly involved with the mishap. Other personnel detracted from their primary billets, due to their participation in either the mishap investigation or reclamation process further reduces a unit's ability to carry out its mission. With personnel shortages effecting all commands throughout the military, mishaps only serve to exacerbate this situation. In the end, costs of aviation mishaps (both to aircraft and personnel) pose a threat to Naval Aviation's ultimate goal, which is to maintain a high level of combat readiness. (Cressy, 1998; Mann, 1998).

B. SAFETY AWARENESS IN AVIATION

1. Historical Roots

Increased safety has long been an issue of concern to those involved with aviation, dating as far back as 1908 with the first fatal air crash. Founded in 1918, the United States Airmail Service stages its first strike in 1919 over safety concerns (Perrow, 1984). The pressures on pilots to fly to meet government and business mail schedules, coupled with aircraft reliability of the times result in a life expectancy of four years. Thirty-one of the first forty pilots die under these conditions (Perrow, 1984). The Army Air Corps' attempts at mail delivery prove equally as disastrous. Beginning service on February 16, 1934, they lose six pilots in the first week. During the next month, six more airman are killed (four of them in a single day) before systems and procedures are established to increase mission safety (Heppenheimer, 1995).

Despite the hazards associated with this newfound occupation, the opportunities the airmail service present are apparent and measures are taken to improve its overall operation and safety. Around 1920, under the direction of E.H. O'Shaughnessy, the airmail service establishes new standards for all applying pilots. These require that all applicants have a minimum of 500 flight hours, pass a qualifying examination and a medical examination prior to being hired. Additionally, aircraft receive frequent inspections, with airframes and engines being overhauled according to a periodic maintenance schedule. (Heppenheimer, 1995).

The idea of commercial aviation, an industry where people paid to fly in aircraft, begins in 1910 with the Delag Airship Company's use of Zeppelins in Germany (Academic American Encyclopedia, 1994). Starting that year, experiments are conducted in the use of airplanes to carry mail, freight, and later passengers (Chambers's

Encyclopedia, 1973). In 1914, the St. Petersburg-Tampa Airboat line operates across Tampa Bay in Florida; and in Russia, a multiengine transport plane flies from St. Petersburg to Kiev (Chambers's Encyclopedia, 1973). Despite these early strides, it is not until after the First World War that commercial aviation truly gets its start. Surpluses of military aircraft, especially bombers, are easily converted to carry passengers. Many European countries take an early lead in the advancement of commercial aviation. Their railroad systems, having suffered extensive damage from the war, provide an opportunity and impetus for early airline entrepreneurs. By the end of 1919, Europe boasts quite an extensive network that links many of its more important cities, including a daily international service from London to Paris (Heppenheimer, 1995).

The United States gets off to a slow start with respect to commercial aviation. Indeed, at the time of Charles Lindbergh's solo Trans-Atlantic flight in 1927, the U.S. has only thirty planes that can be considered airliners, offering no more than two hundred seats (Heppenheimer, 1995). But Lindbergh's feat spurs such an interest in aviation that the number of tickets purchased for commercial flights in 1926 (5,800) increases to 417,000 by 1930 (Heppenheimer, 1995). The U.S. soon establishes itself as the leader in commercial aviation and has maintained that title to this day. Accomplishments of the Airmail service and technological improvements are used to advance the industry. With the application of jet propulsion to commercial air transportation in 1952 (by British Overseas Airline Corporation), more efficient lift capability and faster travel times lead to the introduction of low-fare air tourism to society (Heppenheimer, 1995). This will eventually evolve the industry into one that today carries over 800 million people annually (American Academic Encyclopedia, 1994).

A strong partnership between government and private industries is required for the initial development of aviation. Governmental regulation is crucial to the initial growth of commercial aviation and continues to play a role until the Air Transport Deregulation Act of 1978 (Academic American Encyclopedia, 1994). In Europe before World War I, scientifically trained engineers form research organizations and laboratories, the most notable of these being Britain's Advisory Committee for Aeronautics (1909) and Ludwig Prandtl's aerodynamic research center at Göttingen, Germany. In the United States, the National Advisory Committee for Aeronautics, the predecessor to the National Aviation and Space Administration (NASA), is established in 1915. (American Academic Encyclopedia, 1994).

2. Contemporary Thought

As aviation becomes more commercialized, it inherently becomes more concerned with the issues of safety (Perrow, 1984). Public sentiment demands a continuing, affordable and safe air transportation system. Meshkati (1997) states that "Safety is an emerging force in business with dual financial and marketing effects." Airline travel decreases after large accidents; airframe companies suffer if one of their models appears to have more than its share of problems (Perrow, 1984). Maintenance deficiencies that impact safety of flight can also be linked to flight delays, ground damage and other factors that have a direct impact on airline costs and business viability (Endsley & Robertson, 1999). Over the years, commercial aviation safety will appear to be molded by three various factors; oversight, technology and management.

a. Oversight

Oversight has taken the form of both regulation and research. The first federal attempt to impose safety regulations on civil aviation is made by the Air Commerce Act of 1926 (FAA Website). This created the Aeronautics Branch of the Department of Commerce, which assumes primary responsibility for aviation oversight. This requires the licensing of pilots and certifying of airplanes (amongst other duties).

Since then, several legislative acts enlarge the scope of federal regulation concerning both air safety and commercial routes and fares. Such legislation eventually evolves the Aeronautics Branch into the Federal Aviation Agency in 1958 and to its present day form as the Federal Aviation Administration (FAA) in 1967. Under the Department of Transportation, the FAA regulates all aspects of aircraft safety and is instrumental in the implementation of standardization. (FAA Website, 1999).

In addition to regulatory actions, combinations of incidents and accidents demand that certain attention be given to researching the causes of aviation mishaps or ways to improve maintenance safety (Rogers, 1991). The Socio-Technical Systems (STS) model, an organizational model used to understand purposeful work systems in complex environments for over 40 years, is been used to assess aviation heavy maintenance systems (Pidgeon & O'Leary, 1994). The Aviation Safety Research Act of 1988 mandates that research attention be devoted to a variety of human performance issues including "aircraft maintenance and inspection" (Human Factors in Maintenance Handbook, 1999).

b. Technology

Increases in technology greatly improve the safety of commercial aviation. In the 1930s, gains in wind tunnel testing, maintenance equipment and engine and

airframe design combined to provide faster, larger and more durable airplanes (New Columbia Encyclopedia, 1975). The 1940s see the interruption of commercial aviation by the Second World War. But with its cessation comes the age of the jet engine and a corresponding major change in aviation development that is further advanced by the use of jet aircraft in the Korean Conflict in the 1950s (Heppenheim, 1995). Remarkable advances in the electronics technology from the 1960s to today provide aircraft with state-of-the-art instrumentation, navigation and automation systems. Traffic Collision Avoidance System (TCAS), Global Positioning System (GPS), Ground Proximity Warning System (GPWS) and Instrument Landing System (ILS) are just a few examples of systems that technology has provided which enable aircraft to operate with confidence and safety in virtually any environment (Wiener & Nagel, 1988).

c. Management

Management can be used to manipulate the maintenance effort in order to achieve a safer working environment. Additionally, the management itself can be manipulated into bringing about changes that impact maintenance safety. In the area of maintenance management, "team-approaches" to conducting aircraft maintenance are examined. In 1985, Japan Air Lines (JAL) implements this theory by creating dedicated engineer/maintenance teams called "Kizuki" (meaning "airplane crazy") which are responsible for a specific Boeing 747 aircraft at all times, regardless of its location (Human Factors in Maintenance Handbook, 1999). Also, the U.S. Air Force reports success in utilizing team-based aircraft maintenance organizations (Rogers, 1991). With respect to manipulating management itself, the Airline Pilot Association (ALPA) is a strong union among commercial airline pilots that is very concerned with aviation safety.

It conducts its own studies and makes recommendations in the area of maintenance safety (Perrow, 1984).

3. Military Aviation

In the military, various intervention strategies are implemented over the years to increase safety and reduce the risks of mishaps. In Naval Aviation for example, the earliest of these dates back to 1912 with the Surgeon General's requirement that all aviators pass a flight physical. This was followed shortly after with the institution of psychiatric evaluations following World War I (Bachman, 1918). More recent efforts take the form of engineering constraints: the introduction of the angled flight deck to U.S. aircraft carriers (1952); and systems/administration constraints: the creation of the Naval Safety Center (1954) and Fleet Replacement Squadrons (FRS, 1959); and the Naval Aviation Maintenance Procedures (NAMP, 1959), Naval Air Training and Operating Procedures Standardization (NATOPS, 1961) and the Squadron Safety Program in 1977 (Naval Safety Center Brief 1997). By way of these programs, Naval aviation has effectively increased combat readiness by reducing aviation mishap rates (see Figure 1).

With the 1990s, Naval Aviation (through the HFQMB) sees the implementation of a variety of human factor programs. These programs strive to modify the safety culture of communities by systematic and continual monitoring of the risk factors involved in military flight operations. The first, Operational Risk Management (ORM), is a decision making tool that systematically identifies, assesses and controls the risks involved with conducting a individual mission. The Aircraft and Aircrew Systems plan calls for accelerated installation of aircraft safety systems, such as flight data/cockpit voice recorders, ground proximity warning systems and midair collision avoidance systems. The Aircrew Coordination Training (ACT) program improves coordination and

teamwork among the members of a given aircrew by way of computer and video-aided debriefs following aircrew simulation training (Nutwell & Sherman, 1997). Finally, the CSA (being based on the Model of Safety Effectiveness components) draws its strength from incorporating many of these proven high-risk traits. It's utility as a tool for Commanding Officers and Aviation Safety Officers (ASOs) to assess their command's safety posture is receiving increasing attention.

These aforementioned programs are currently serving to facilitate and enhance the success of Naval Aviation's current safety environment as evidenced by the 1997 Class 'A' Flight Mishap rate of 1.96 accidents per 100,000 flight hours flown being the second lowest in history. To supplement these programs and encourage the development of new/additional ones, it is beneficial have an understanding of the complexities of high-risk organizations and how they can benefit from the concept of a corporate safety culture.

C. HIGH-RELIABILITY ORGANIZATIONS

The notion of a poor safety culture receives widespread attention in accounts of the human and organizational errors underlying the 1986 Chernobyl nuclear power plant accident in the former Soviet Union (Turner, Pidgeon, Blockley & Toft, 1989; Pidgeon, 1991). Analysis of the disaster prompts hindsight claims that Soviet engineers had a worse safety culture than is present in the west. But despite this claim of a better safety climate, western industry sees its share of large-scale incidents. These include the 1979 Three Mile Island nuclear power plant accident, the 1984 Union Carbide petrochemical plant gas leak, the 1986 Challenger space shuttle accident and the 1989 Exxon Valdez oil

tanker spill. Although these accidents occur throughout a variety of organizations, they all have one thing in common– they are all high-risk organizations. That is, they are all organizations with catastrophic potential– the ability to take the lives of hundreds of people in one blow, or to shorten or cripple the lives of thousands or millions more (Perrow, 1984).

What makes these HROs so potentially dangerous is that their level of technical complexity makes them vulnerable to accidents or failures that can not be predicted during the design process (Roberts, 1990). Though rare, catastrophic accidents tend to occur due to a myriad of interactions within components of the overall system. This "interactive complexity" is a characteristic of the system, not of a specific part or operator, and is exaggerated when the system is "tightly coupled" (Perrow, 1984). Perrow describes systems as being tightly coupled when processes happen too quickly to be prevented. Usually, one malfunction triggers a malfunction within another independent part of the system and recovery from the initial disturbance is not possible. This is in contrast to "loosely coupled" systems, which Perrow describes as systems that can still have multiple failures, but these failures occur independently without one having caused the other.

Organizations utilizing tightly coupled systems pose a much higher challenge to safety issues because they are difficult for an operator to diagnose and correct. Additionally, operator actions or the safety systems in place may only serve to exaggerate a malfunction while attempting to apply corrective action, thereby making things worse. This is because it may be some time before the nature of the problem is known. Risk will never be eliminated from these systems, but through experience, better designs and

procedures, tight coupling can be reduced (Perrow, 1984). And it is through the implementation of a safety culture that these organizations can further reduce hazardous situations.

D. CORPORATE SAFETY CULTURE

A corporate safety culture is a specific set of norms, beliefs, roles, attitudes and practices within an organization which is dedicated to minimizing exposure of employees, managers, customers, suppliers and members of the general public to conditions considered to be dangerous or injurious (Turner, 1991; Pidgeon, 1991). The ultimate goal of a corporate safety culture is to minimize accidents by establishing a firm foundation in which safety is considered to be a priority. Characteristics of a good safety culture can be grouped into three areas– norms and rules for handling hazards, attitudes toward safety and reflection on safety practices (Pidgeon, 1991).

1. Norms and Rules

Norms and rules governing safety within an organization are at the heart of a safety culture. As guidelines for action, these shape the perceptions and actions of individuals within an organization as to what is and what is not to be regarded as a significant risk. Understanding this aids the individual in selecting an appropriate response when confronted with an unsafe situation (Turner, et al, 1989). A caution here is to guard against implying that the procedures established are the only rules by which all foreseeable hazards can be avoided. This leads to the inflexible or ritual application of existing rules to situations in which they may not apply. This is referred to as a form of cognitive "mind-set" or "groupthink" (Weick & Roberts, 1993). Preventing this pitfall requires a willingness to monitor ongoing technologies in diverse ways. This may

include soliciting opinions about risk from outsiders; implementing positive reward structures for personnel who identify and report unsafe conditions, and encouraging creativity and imagination in developing and implementing safety procedures (Pidgeon, 1991).

2. Safety Attitude

"Safety attitude refers to individual and collective beliefs about hazards and the importance of safety, together with the motivation to act on those beliefs" (Pidgeon, 1991). This attitude can be achieved by the positive promotion of its corresponding ideals. But corporate cultures are notoriously resistant to change (Turner, et al, 1989). Change requires total dedication on the part of the organization, and anything less than total dedication will impact workers' perceptions of management's dedication to the seriousness of this topic. Zohar (1980) found that companies that have successful safety programs (and corresponding low accident rates) are those in which management maintains a strong commitment to safety. This commitment is demonstrated by active participation in safety activities on a routine basis. Zohar (1980) also found that companies with low accident rates are those in which safety officers hold a position of high rank or status.

If approached correctly, the safety culture concept can create a synergetic affect. Turner (1991) states that "one of the most potent ways of influencing behavior is through group pressure". This serves the organization in two ways. One is that the existing attitudes exert a powerful influence on new employees, molding them into the prevailing ways of thinking and behaving. Another is the fact that an organization with a positive reputation for safety will tend to attract personnel with similar ideals.

3. Reflection on Safety Practices

Reflection upon an organization's current practice is the final characteristic critical to a good safety culture. This is best accomplished by mechanisms that provide for the generation of accident and incident feedback (Turner, et al, 1989). Two ways of achieving this are by implementing a reward system and by ensuring a "no-fault" reporting system (Eiff & Mattson, 1998). A reward system offers incentives to individuals who report unsafe conditions. A "no-fault" reporting system ensures that no retribution is brought to bear against anyone identifying an unsafe situation. A study by Westrum (Turner, 1991) shows that a key element in ensuring reliable performance with respect to obtaining feedback on unsafe conditions is an atmosphere in which mistakes can be discussed openly and without fear of recrimination. In doing so, these events can serve as learning opportunities. All too often, accidents that could have been avoided or prevented in the future are covered up, only to be rediscovered when they have produced far more serious consequences.

E. ASSESSING HIGH RELIABILITY ORGANIZATIONS

Roberts (1988) states that existing organizational research is of little help in understanding the organizational processes that defined HROs. Her claim is that the current literature claims there was no difference between the way an HRO and other less hazardous organizations conduct business. Her belief that HROs embody certain key characteristics (such as leadership style, management policies, procedures standardization, superior training, reward systems) and subsequent research sets the ground work that would eventually lead to Libuser's 1994 Model of Organizational

Safety Effectiveness (MOSE). This model organizes the traits of HROs into the five categories of Process Auditing, Reward System, Quality Assurance, Risk Management and Command and Control. It is off this model that Ciavarelli and Figlock (1997) will base their CSA in an attempt to assess the HRO aspect of Naval Aviation through the perspective of aircrew.

Baker (1998) will take this process one step further. In attempting to identify the contribution that maintenance plays in aviation safety, results from benchmarking and mishap data analysis (with respect to Naval Aviation maintenance operations) are utilized in conjunction with Civarelli & Figlock's CSA. Where the CSA assessed safety from an aircrew perspective, Baker develops a 67-item questionnaire that assesses safety from the perspective of aircraft maintainers. Additionally, Baker's research constitutes the incorporation of a sixth component to the existing MOSE: Communication / Functional Relationships. Appendix A contains the elements that comprise each of the six MOSE components used in Baker's research, which concludes with the reduction of his questionnaire from 67 to 35 items.

Continuing where Baker left off, this thesis will further explore the attitude of Naval Aviation maintenance personnel with respect to safety. In addition, it will attempt to identify any commonality or differences in the safety posture of maintenance personnel between different communities within a Naval Reserve Wing. To do so, it will utilize the 35-item questionnaire; a tool developed out of the concept of these high-risk organizations and corporate safety cultures.

F. SUMMARY

High-risk organizations operate in a stressful environment. They must balance their day-to-day operations with the possibility of encountering a potentially disastrous situation; a situation that may be set into motion by a seemingly small or even unimportant event. But despite this heavy burden, many of these organizations seem to prevail by the incorporation of the concept of a safety culture.

Naval Aviation can benefit from the incorporation of procedures proven successful in other HROs. By implementing practices designed to establish and foster an organizational safety culture, safety awareness can permeate all levels of Naval Aviation operations. From managing the maintenance effort to the maintenance itself, a positive safety posture is imperative, and there is a need to assess safety attitudes both within and across communities to gain an overall perspective. One way to accomplish this is through the use of the MCAS.

The organization that wants to promote safety and develop this type of culture works with a natural advantage. Turner (1991) states that people have an innate concern with safe, non-harmful ways of working. And due to the self-sustaining nature of these safety culture ideals, an organization that implements these practices correctly stands only to gain from its investment.

III. METHODOLOGY

A. RESEARCH APPROACH

The intent of this study is to assess the maintainer's perception of safety and to achieve an understanding of the risks within their organization. This research involves analysis of the collected survey results and employs an existing model to identify organizational factors in an attempt to improve safety within the aviation maintenance community. Additionally, the results from this survey are supplied to the Commander, Naval Air Reserve Force (NARF) to keep him apprised of his Type Command's perspective on maintenance safety and aid in developing a proactive safety environment. This study involves the analysis of data from a climate assessment survey that is based on an existing model of high-reliability organizations. This is done to identify any factors that may be utilized in the improvement of safety in aviation maintenance practices. The data analysis entails principal component analysis, cluster analysis, analysis of variance, multiple comparison analysis and descriptive statistics.

B. DATA COLLECTION

1. Subjects

A total of eight Naval Air Reserve Force (NARF) Squadrons are surveyed. This mixture consists of two Helicopter Antisubmarine Light (HSL) Squadrons, two Fixed Wing Maritime Patrol (VP) Squadrons and four Fixed Wing Fleet Logistics (VR) Squadrons. The HSL Squadrons are based at Naval Air Station (NAS) North Island, CA. and NAS JRB, Willow Grove, PA. The VP Squadrons are stationed at NAS JRB, Willow Grove, PA and Moffett Field, CA. The Willow Grove data is actually collected

for this thesis and compared / pooled with the Moffett Field data from Baker's thesis research. VR data is obtained from squadrons located at NAS JRB, Willow Grove, PA.; NAS New Orleans, LA.; NAS Norfolk, VA; and NAS Brunswick, ME. The survey respondents are primarily Enlisted Navy personnel assigned to aviation maintenance departments. Their duty status consists of either Selected Reserve (SELRES) or Training and Administration of Reserves (TAR) status. No civilians participate in the survey.

2. Instrument

The Maintenance Climate Assessment Survey (MCAS) is the final product of Baker's 1998 NPS Master's Thesis. It consists of a self-administered, group survey with 15 demographic and 35 maintenance related questions. Appendix B contains Baker's proto-type 67-item questionnaire and Appendix C contains the 35 item MCAS. Demographic questions cover the areas of rank, community, service component, shift worked, total years of service and total years of aviation maintenance experience. Additionally, education level, unit home location, rating, age, and maintenance qualifications are addressed in this section. Additionally the demographic questions maintain the respondent's anonymity by neglecting to ask for name, social security number or work section. The survey utilizes a Likert type five point rating scale with verbal anchors as follows: Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree.

3. Procedure

The surveys are conducted in person during either safety stand-downs or during the reserve duty drill weekend. An overview is given with respect to the survey and its purpose, addressing groups as a whole. The survey is distributed, and any questions that arose are promptly answered. Respondents are allowed as much time as necessary to

complete the surveys with the mean completion time being around 20 minutes. The surveys are collected immediately upon completion to allow for maximum accountability.

C. DATA ANALYSIS

1. Data Tabulation

Survey demographics and responses are hand entered into an Excel (Microsoft, 1997) spreadsheet. The spreadsheet consists of rows of respondents and columns of survey questions. The first fifteen columns are for demographics, with another thirty-five columns representing the actual survey questions. Results are coded in the spreadsheet by assigning scores of 1, 2, 3, 4, or 5 corresponding to the Likert scale of Strongly Disagree, Disagree, Neutral, Agree and Strongly Agree, respectively. Survey questionnaire items that have no response are coded with "Blank" and are dealt with by S-PLUS (Mathsoft, 1997) as the data is transformed into a SPLUS 4.5 data frame for complete data analysis.

2. Statistical Analysis

Basic summary statistics are developed. Bar charts are used for initial familiarization and identification of any possible problems with the data set. Next a principal component analysis is performed on the data in an attempt to identify any commonality of loadings across the MOSE components. Cluster analysis, utilizing both agglomerative nesting and divisive analysis methods are conducted to determine the clustering structure of the survey and identify any possible clustering of MOSE components. Analysis of Variance (ANOVA) and multiple comparison testing are utilized to identify any differences between either the communities surveyed or the

MOSE components with respect to survey outcome. Descriptive analysis is conducted on the data to describe basic and general information about the demographic and question results. These results include the distribution of survey participants by rank and service classifications, and the total sample, mean and standard deviation for each of the 35 survey questions.

IV. RESULTS

A. DATA EXPLORATION

Five hundred three (503) surveys are collected in the process of this thesis. Of these, four hundred thirty nine (439) indicate actual maintenance experience. The anaylsis of those 439 surveys is addressed here.

1. Bar Chart Analysis

Bar charts are used to determine its underlying structure. Using the Trellis Graphics package in S-PLUS 4.5 (Mathsoft, 1998), bar charts for the responses to each of the 35 survey questions are developed. Each community's results are plotted together on a single sheet for comparison (see for example Figure 4).

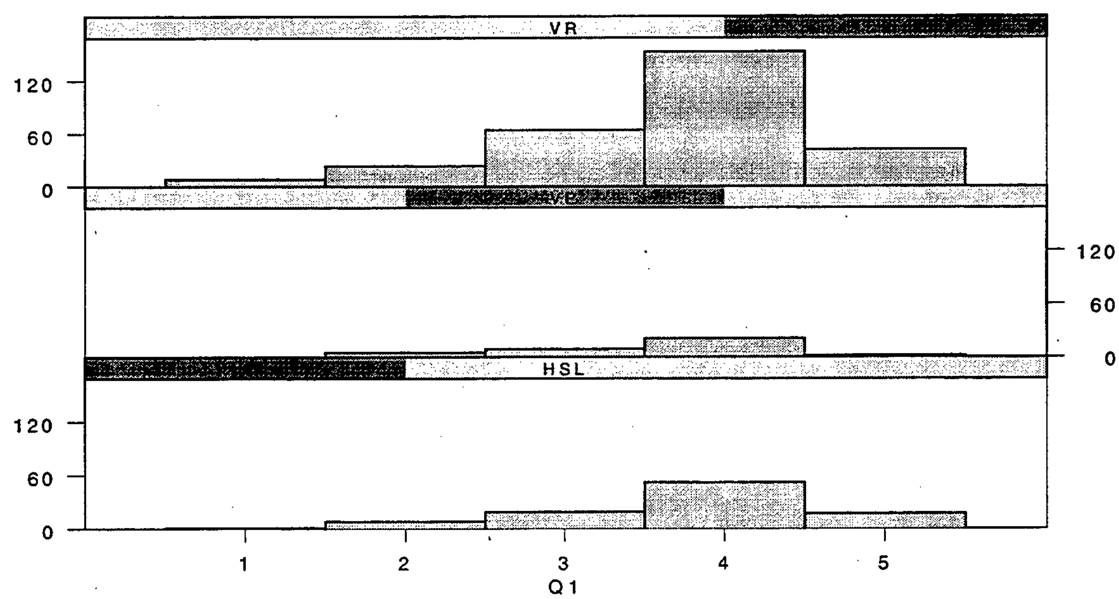

Figure 4. Histogram of Responses for Question 1 by three Communities; VR, VP and HSL.

The horizontal scale on the bar-plots represent the Likert scale responses (1-5) and the vertical scale indicates the number of respondents per community. Overall, the data is found to be unimodal in structure and not too lacking in symmetry. Thus it is not uncomfortable to use the normal distribution in subsequent analysis.

2. Principal Component Analysis

Principal Component Analysis is performed on the data in an attempt to identify any common loading of MOSE categories across the major contributing components accounting for the majority of the variance within the questionnaire. Table 1 shows the six MOSE categories used in Baker's thesis and the questions that comprise each (see Appendix A for questions by model component).

MOSE Category	Questions
Process Auditing	1, 2, 6, 8
Reward System	4, 13, 14, 25, 32
Quality Assurance	3, 7, 12, 16, 22, 26, 28, 29, 30
Risk Management	9, 15, 24, 31, 34
Command & Control	11, 17, 18, 19, 23, 35
Communication & Relationships	5, 10, 20, 21, 27, 33

Table 1. MOSE Categories and Questions.

Using the S-PLUS statistical system, the command "princomp (X, na.action = na.omit, cor = T)" was applied for the principal component analysis. The input "X" is the 439 by 36 matrix of survey responses. The code "na.action = na.omit" is required in order for S-PLUS to handle cases where blanks occur in the data. S-PLUS treats missing values (coded NA) by omitting them in the performance of a principal component analysis. Forty-six cases are discarded from the original data due to missing values. This reduces the number of cases evaluated in the principal component analysis to 393. The

"cor = T " implies that the analysis is based on a correlation matrix rather than a covariance matrix. A scree-plot displays each component's contribution to the total variance and is displayed in Figure 5.

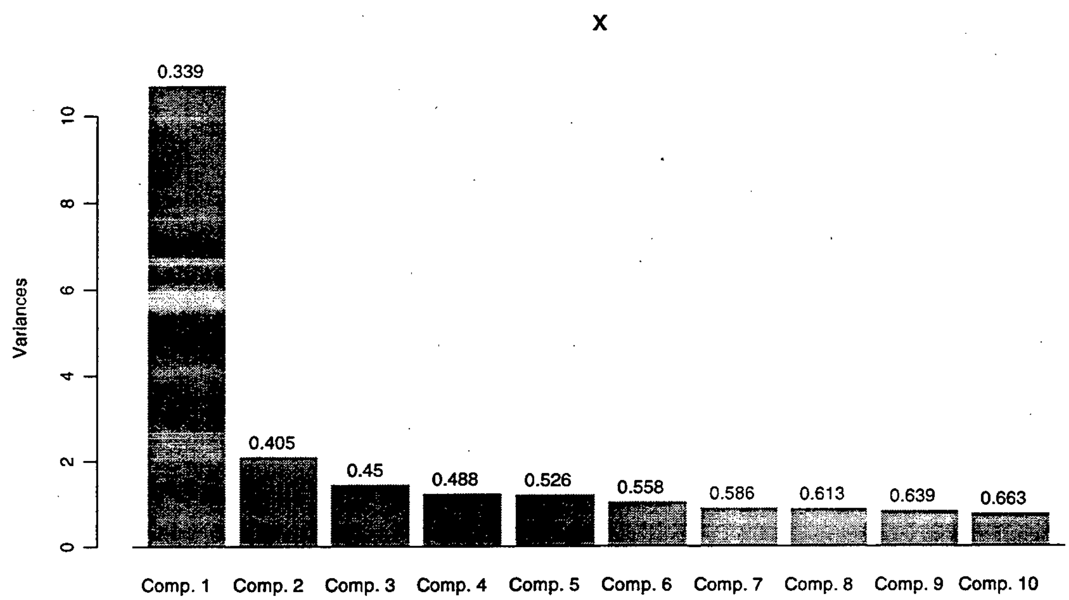

Figure 5. Principal Component Screeplot.

Above each bar in Figure 5 is the cumulative percentage of variance accounted for by each component and its predecessors. Over one-third of the variance is accounted for by the first component, with the remaining variance being spread relatively evenly across all other components. This shows evidence that the survey data possess one major dimension.

Figure 6 displays the first five components and the six variables that have coefficients or loadings with the largest magnitude for each component.

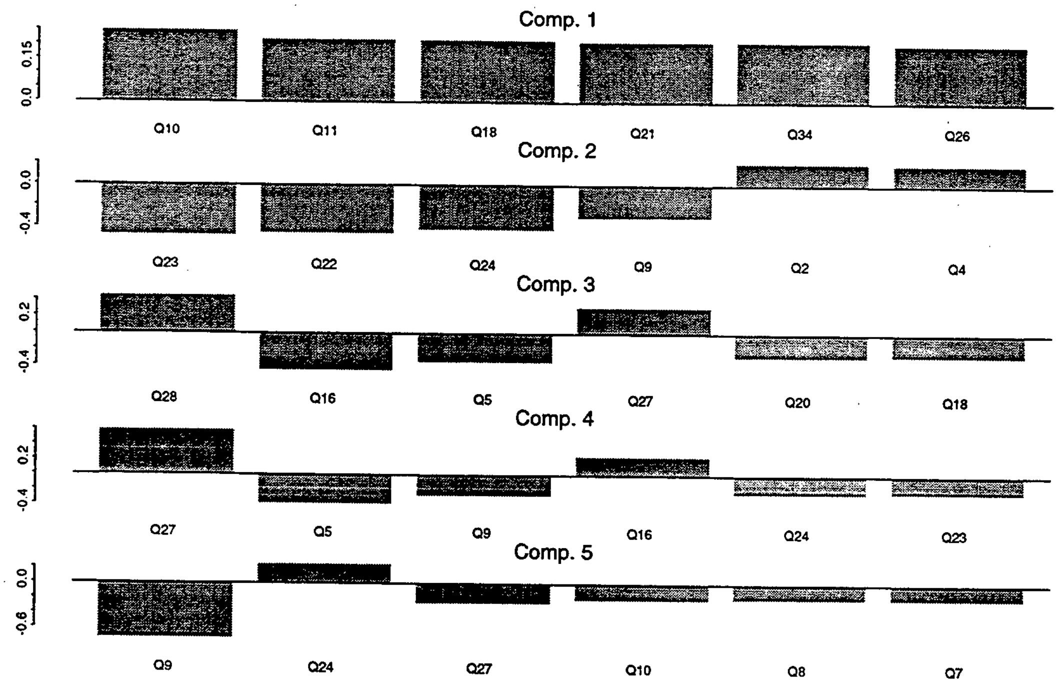

Figure 6. Loadings Plot of the first five Principal Components.

Identifying the questions that load upon Component 1 reveals that four of the six MOSE categories are represented. Thus, it cannot be said that any single MOSE category contributes to the majority of the variance within the survey. This is consistent in evaluating the remaining four principal components, which comprise over fifty percent of the total variance and represent anywhere from three to five MOSE categories in each component.

3. Clustering

Cluster analysis is a method of classifying a data set into isolated groups that are internally cohesive. Clustering analysis is performed on the 35 questions to determine if items clustered according to MOSE category. Two methods by which this can be achieved are hierarchical agglomeration and divisive analysis (S-PLUS 4 Guide to Statistics, 1997). Though the two methods attempt to achieve the same end product (the

separation of the data into groups), their algorithms operate in opposite fashions. Thus, it is wise to apply both methods to see if their results agree.

a. Agglomerative Nesting (AGNES).

Agglomerative nesting is an algorithm that constructs a hierarchy of clustering. Considered a "bottom-up" approach, the S-PLUS agglomerative nesting algorithm is called "AGNES". At first, each observation is a small cluster by itself. During each stage of the algorithm, the two "nearest" clusters are combined to form one larger cluster. The algorithm is based on dissimilarities. In AGNES, the distance between these clusters is determined via one of two metrics. The currently available options are "euclidean" and "manhattan". Euclidean distances are root sum-of-squares of differences, and manhattan distances are the sum of absolute differences. If the data set is already a dissimilarity matrix, then the distance metric is not required. Clusters are merged until only one large cluster remains, which contains all the observations.

The S-PLUS code for this analysis is "agnes (daisy (t (X)), diss= T)." The S-PLUS function "daisy" is used to calculate the dissimilarity matrix for the data set "X." The data set is transposed through the code "t (X)" so as to permute the clustering across the survey questions, vice the cases. The "diss=T" statement implies that a dissimilarity matrix will be used in the algorithm's computation of the distance function. The output of the AGNES analysis is displayed in a tree type diagram (or dendrogram). The command "plot (*name*)" is used to obtain the dendrogram, where "*name*" is any arbitrary name assigned to the analysis. The resulting AGNES analysis is shown in Figure 7. The leaves of the tree are the survey questions. Two branches are joined at the distance of the

two clusters being merged, measured by the vertical (height) scale at the left side of the dendrogram.

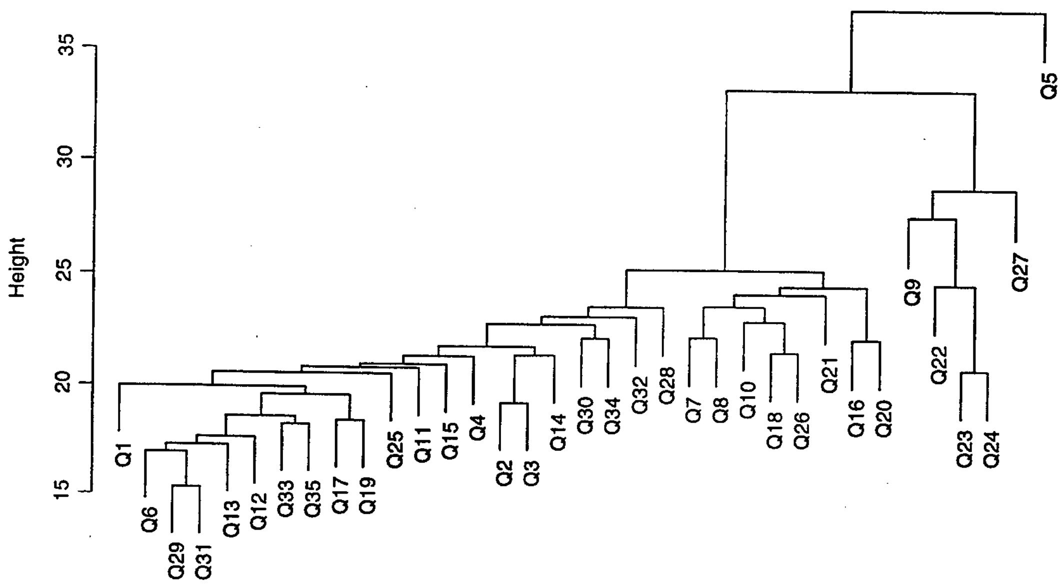

Figure 7. AGNES Clustering Dendrogram

An agglomerative coefficient measures the amount of clustering structure of the data set. An agglomerative coefficient of one (1) would indicate a perfect clustering structure and a zero (0) would indicate no clustering structure. The resulting agglomerative coefficient produced from performing AGNES on the data set was 0.42.

b. Divisive Analysis (DIANA).

Divisive analysis is a form of cluster analysis that divides a data set into groups (clusters) of observations that are similar to each other. Considered a "top-down" approach, it begins with one large cluster containing all "n" items. Dissimilarities are

used to determine how to divide the data set. The initial split is conducted by finding the most disparate item in the group (i.e. the one with the highest average dissimilarity to all other objects). This item forms the nucleus of what is called the "splinter group" (S-PLUS 4 Guide to Statistics, 1997). Then for each item outside the splinter group, average distances are computed to all other items and to the splinter group. Items that are closer to the splinter group than any other item are added, otherwise it is paired with whichever item it was closest to. The process continues until the data is split into two groups. In each subsequent step of the algorithm, the largest available cluster (i.e. the one with the highest dissimilarity) is put through the same process as just described with the initial split. The process is repeated until each cluster contains only a single item.

The S-PLUS code used to perform the divisive analysis on the data set is "diana (daisy (t (X)), diss= T)." The S-PLUS function "daisy" is used to calculate the dissimilarity matrix for the data set "X." The data set is transposed through the code "t (X)" so as to permute the clustering across the survey questions, vice the cases. The "diss=T" statement implies that a dissimilarity matrix will be used in the algorithm's computation of the distance function. A dendrogram of the results is plotted using the code "plot (*name*)," where "*name*" is any arbitrary name assigned to the divisive analysis. Figure 8 shows the output of the divisive analysis run on the data set.

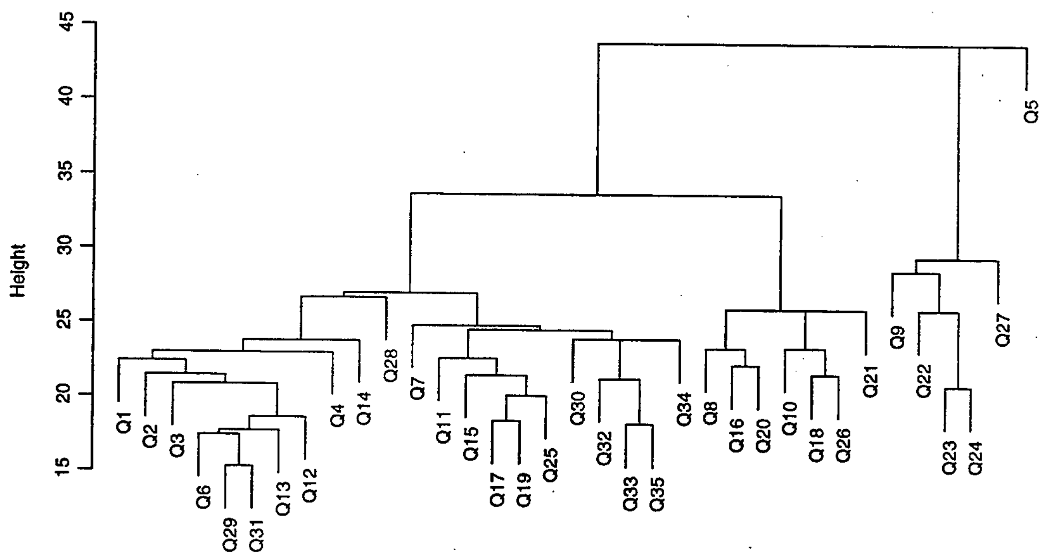

Figure 8. DIANA Clustering Dendrogram.

Evaluation of the AGNES and DIANA dendrograms reveals very similar clustering results. Though there is no distinct clustering by MOSE categories, the items do group similarly when both agglomerative nesting and divisive analysis were performed on the data set. The divisive coefficient, which measures the clustering structure of the data set, was measured at 0.49. This closely reflects the agglomerative coefficient of 0.42 obtained through AGNES and further backs the stability of the survey.

4. Descriptive Statistics

a. Demographics

Descriptive statistics are developed for the survey respondents. Maintenance personnel account for approximately 87.3 percent of the total number of surveys collected for this thesis. A demographic breakdown for each community's maintenance personnel (segregated according to rank) is presented in Table 2. The

percentage each rank category in Table 2 contributes to the overall total number of maintenance personnel both per community and overall is presented in Table 3.

Community	BLANK	E1-E3	E4-E6	E7-E9	Officer	Grand Total
HSL	2	11	73	10	5	101
VP	2	1	27	6	1	37
VR	3	26	213	25	34	301
Grand Total	7	38	313	41	40	439

Table 2. Frequencies of Maintenance Personnel Ranks by Community.

Community	BLANK	E1-E3	E4-E6	E7-E9	Officer
HSL	2.0 %	10.9 %	72.3 %	9.9 %	5.0 %
VP	5.4 %	2.7 %	73.0 %	16.2 %	2.7 %
VR	1.0 %	8.6 %	70.8 %	8.3 %	11.3 %
Grand Total	1.6 %	8.7 %	71.3 %	9.3 %	9.1 %

Table 3. Percentage of Maintenance Personnel Ranks by Community.

To aid in visualizing the distribution of personnel throughout the respective communities, Figure 9 displays the information presented in Table 3. Immediate attention is drawn to the disproportionate distribution of personnel among the E4-E6 rank category, which makes up approximately 71 % of the total population of maintenance personnel. This distribution is also fairly consistent across each community. This is something to make note of in the fact that the majority of the maintenance performed and direct supervision come from this pool of personnel. This group encompasses anywhere from two to twenty-eight years of military service (with an average of just over eleven years) and anywhere from one to thirty-four years of maintenance experience (with an average of approximately ten and one-half years).

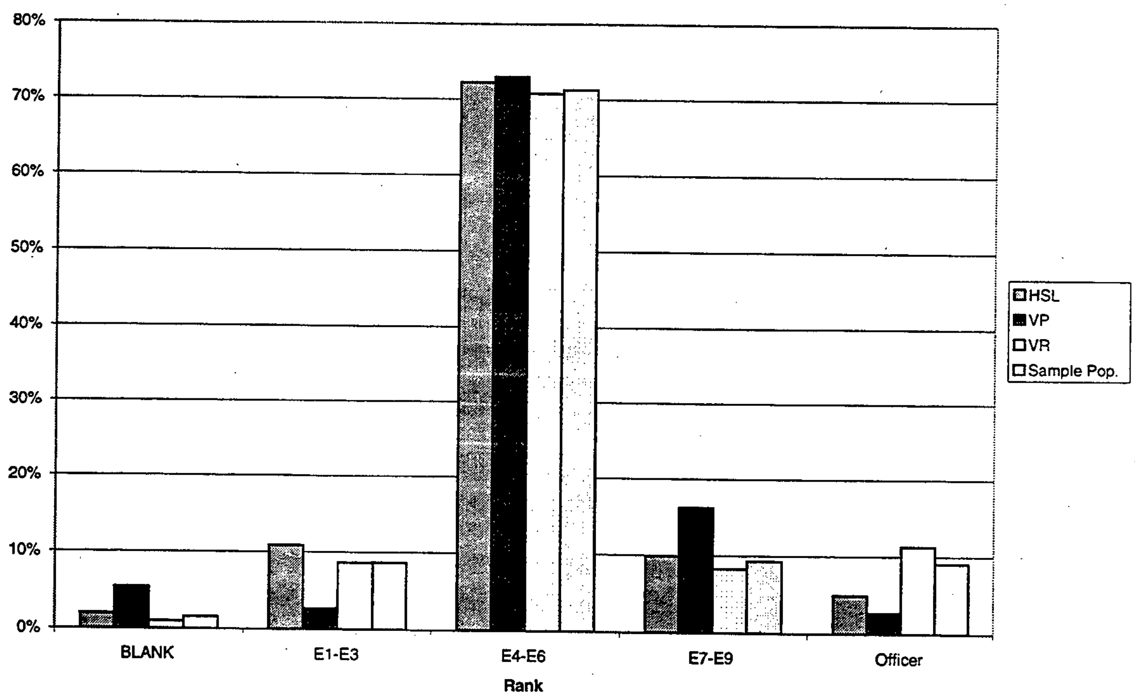

Figure 9. Percentage of Maintenance Personnel Ranks by Aircraft Community.

b. MOSE Component Evaluation

The results from evaluating the MOSE categories are displayed in Tables 4 through 10. Each table contains a list of all questions from the appropriate MOSE category, the average response per community for that question on a "1" to "5" Likert rating scale, and the overall average response per question. The standard deviation corresponding to each question is also included. The analysis reveals that in an overwhelmingly majority of the cases, the average response per question is very similar. This holds in cases where a negative response (i.e. average less than 3.0) was recorded. Also noted is that for the two negatively anchored questions in the survey (i.e. disagreement is a constructive response), the responses for each reflected accordingly. These will be addressed during the individual discussion of each appropriate MOSE category.

The first MOSE category to be evaluated is Process Auditing (PA), which is represented by four questions in the survey. All questions were answered positively with a mean range from 3.22 to 4.34 (see Table 4).

Question	Aircraft Community							
	HSL		VP		VR		Combined	
	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev
1	3.81	0.150	3.54	0.803	3.68	0.261	3.67	0.135
2	4.34	0.020	3.92	0.759	4.25	0.334	4.17	0.221
6	3.97	0.046	3.94	0.743	3.95	0.176	3.95	0.015
8	3.23	0.113	3.22	0.787	3.24	0.158	3.23	0.010

Table 4. Process Auditing MOSE Component Summary.

The second MOSE category is Reward System (RS), consisting of five questions. All questions were answered positively with a mean response ranging from 3.49 to 4.14 (see Table 5).

Question	Aircraft Community							
	HSL		VP		VR		Combined	
	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev
4	3.78	0.077	3.76	0.955	3.84	0.192	3.79	0.041
13	4.03	0.158	3.89	0.774	3.92	0.186	3.94	0.073
14	4.11	0.084	4.14	0.536	3.93	0.201	4.06	0.113
25	3.61	0.126	3.49	0.837	3.57	0.152	3.55	0.061
32	3.65	0.112	3.68	0.784	3.56	0.135	3.63	0.062

Table 5. Reward System MOSE Component Summary.

Table 6 displays the information from the third MOSE category, Quality Assurance (QA). Consisting of nine questions, it contains the largest number of questions for a single category. All have an average response greater than 3.0, except for Question 22, which addresses the area of adequate staffing levels.

Of the three communities, two of them answered this question in a negative manner with average responses of 2.56 and 2.61 (the HSL and VR communities respectively). The VP community answered this question in a positive manner with a average response of 3.19. This also corresponds with the VP data from Baker's (1998) which gives this question (though different in number and wording, addressed the issue of staffing level) an average response of 3.07. Appendix D contains a mapping of the items from Baker's (1998) prototype questionnaire to the 35 item MCAS for use in cross-referencing any items. Though the VP community doesn't rate this question negatively, the fact that the others do should draw attention to it as it addresses the area of sufficient staffing which can definitely effect safety in a variety of ways. The remaining questions are positively answered with means ranging from 3.16 to 4.35.

Question	Aircraft Community							
	HSL		VP		VR		Combined	
	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev
3	4.35	0.112	4.22	0.630	4.19	0.399	4.25	0.085
7	3.51	0.188	3.48	0.768	3.48	0.121	3.49	0.017
12	4.00	0.084	3.97	0.644	3.99	0.261	3.98	0.015
16	3.16	0.115	3.45	0.900	3.41	0.149	3.34	0.157
22	2.56	0.420	3.19	1.009	2.61	0.128	2.78	0.350
26	3.38	0.070	3.56	0.867	3.46	0.219	3.46	0.090
28	3.94	0.118	3.94	0.524	3.77	0.415	3.88	0.098
29	4.19	0.101	4.02	0.552	3.95	0.286	4.05	0.123
30	3.73	0.185	3.56	0.800	3.59	0.314	3.62	0.090

Table 6. Quality Assurance MOSE Component Summary.

Risk Management (RM) is the fourth component in the MOSE model and is comprised of five questions. Three of them were answered positively (mean range from 3.54 to 4.04. Two of them (Questions 9 and 24) are answered in a negative fashion. Question 9 shows all three communities answering negatively with an overall mean response of 2.69. This question addresses manning issues and operational commitments. This is similar to the negative answering of Question 22 in that it addresses manpower issues and should be an area of concern with respect to safety.

Question 24 refers to the area of personnel turnover and was responded to negatively by two of the three communities. The HSL and VR communities both responded negatively with mean responses of 2.75 and 2.88 respectively. The VP community responded positively with a mean response of 3.21. This coincides with data obtained from Baker's (1998) thesis where the VP community scored a 2.88 to Question 40 which addresses the same topic but is negatively anchored. With a negatively worded question, a score below 3.0 implies a positive response and thus is consistent with the VP data obtained during this thesis research. Despite the VP community's positive response, the negative responses obtained from the HSL and VR communities should highlight this area for investigation. Table 7 summarizes the results of the Risk Management component.

Question	**Aircraft Community**							
	HSL		**VP**		**VR**		**Combined**	
	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev
9	2.69	0.200	2.62	1.009	2.77	0.109	2.69	0.075
15	3.67	0.082	3.78	0.821	3.65	0.288	3.70	0.070
24	2.75	0.037	3.21	0.854	2.88	0.159	2.94	0.237
31	4.04	0.087	3.83	0.646	3.91	0.243	3.92	0.105
34	3.77	0.159	3.83	0.833	3.54	0.199	3.71	0.153

Table 7. Risk Management MOSE Component Summary.

The fifth component in the MOSE model is Command & Control (CC). Containing six questions, all but one was answered positively with means ranging from 3.35 to 3.79. Question 23, which addresses the areas of multiple job assignments and collateral duties, was scored negatively by all communities (average response of 2.78). A negative perception in this area should draw some concern. Table 8 displays the results for this MOSE component.

Question	**Aircraft Community**							
	HSL		**VP**		**VR**		**Combined**	
	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev
11	3.45	0.068	3.62	0.981	3.69	0.371	3.58	0.123
17	3.71	0.177	3.78	0.672	3.72	0.119	3.73	0.037
18	3.39	0.172	3.35	1.183	3.46	0.227	3.40	0.055
19	3.79	0.023	3.59	1.012	3.63	0.184	3.67	0.105
23	2.60	0.047	2.94	0.998	2.78	0.122	2.77	0.170
35	3.67	0.263	3.48	0.869	3.76	0.234	3.63	0.142

Table 8. Command & Control MOSE Component Summary.

The last component of the MOSE is Communication & Functional Relationships (CR) which is comprised of six questions (including the only two negatively worded questions in the survey). Of the two negatively worded questions, only Question 5, which addresses problems with passdown between shifts was negatively responded to. Again, being that the question is negatively worded, a negative response (value below 3.0) would indicate a positive perception with respect to safety. The overall mean-response of the HSL community to this question was a 3.02, but it was the result of averaging together the individual responses of the two squadrons within that community. While one rated this question a 2.78 (which indicates a positive response), the other averaged a 3.27 (which implies a negative response). Only one squadron answered in

this fashion and there are two possible explanations: the question was misinterpreted, or the squadron did indeed perceive a problem with this area. The resulting average value of 3.02, though not heavily negative, points to addressing this issue.

The other negatively worded question (27), recorded all positive responses implying no problems with Maintenance Control's ability to troubleshoot discrepancies. The remaining questions provided a mean range from 3.09 to 3.87 (see Table 9).

Question	Aircraft Community							
	HSL		VP		VR		Combined	
	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev
*5	3.02	0.346	2.54	0.690	2.82	0.253	2.79	0.241
10	3.14	0.080	3.10	1.100	3.25	0.319	3.16	0.077
20	3.17	0.063	3.29	0.811	3.09	0.185	3.18	0.100
21	3.24	0.457	3.56	0.987	3.38	0.328	3.39	0.160
*27	2.80	0.424	2.81	0.938	2.78	0.318	2.79	0.015
33	3.87	0.221	3.78	0.629	3.77	0.184	3.80	0.055

Table 9. Communication & Functional Relationship MOSE Component Summary. (* Indicates A Negatively Worded Question).

The overall means for all six MOSE categories are presented in Table 10. The distributions of these results are depicted via a histogram in Figure 10. Additional histograms for each individual MOSE component are enclosed in Appendix E.

Community	PA	RS	QA	RM	CC	CR
HSL	3.83	3.83	3.65	3.39	3.43	3.21
VP	3.65	3.78	3.71	3.45	3.46	3.18
VR	3.78	3.76	3.61	3.35	3.50	3.18

Table 10. Mean Average Response per MOSE Component by Community.

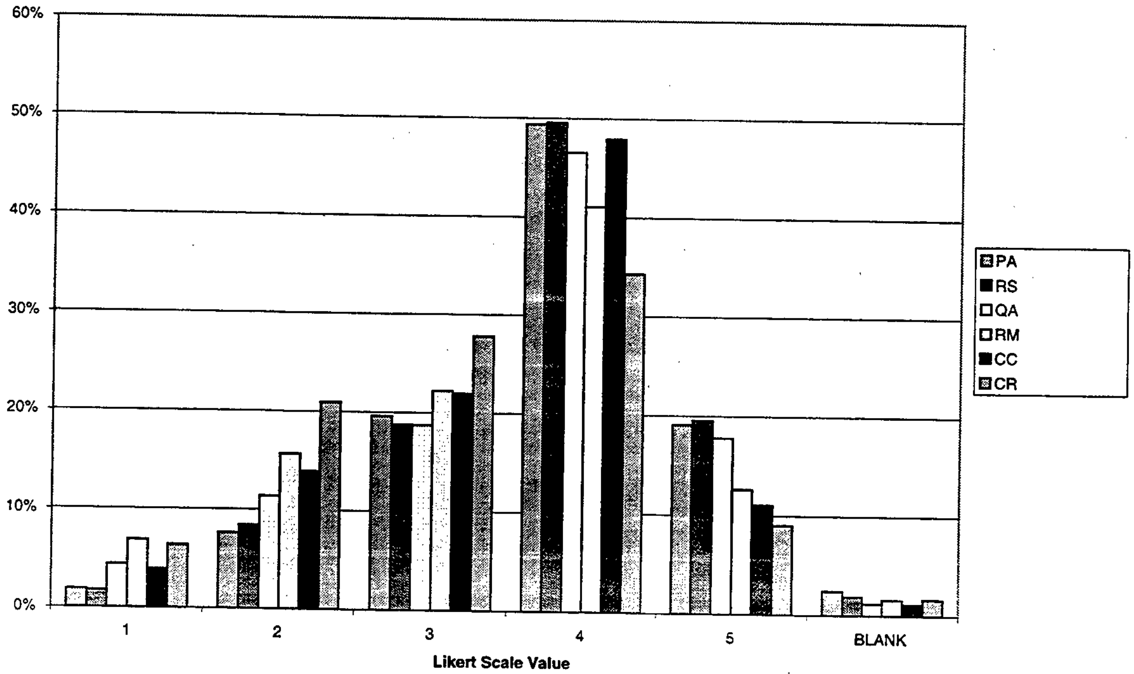

Figure 10. Distribution of Model Of Safety Effectiveness Ratings.

5. Analysis of Variance (ANOVA)

A two-factor analysis of variance (ANOVA) is run to determine if either Community or MOSE category have an affect on the mean survey response. In a two-factor ANOVA, there are two hypotheses of interest. The first states that the different levels of factor "A" have no effect on the true average response and was denoted H_{0A}. The second states that there was no effect from factor "B" and was denoted H_{0B}.

The letter "*I*" denotes the number of levels of the first factor of interest (factor "A" or Community) and "*J*" denotes the number of levels of the second factor of interest (factor "B" or MOSE category). With I=3 (the three aircraft communities) and J=6 (the six MOSE categories), there were IJ (or 18) possible combinations consisting of three levels of factor "A" and six of factor "B." Each such combination was viewed as crossed

levels of the two factors. There is only one result for each possible cell and the analysis utilizes a two-factor ANOVA with one observation per cell. The factors, levels and data are shown in Table 11. The ANOVA table obtained from running the two-factor ANOVA is given in Table 12.

Community	MOSE Categories					
	PA	RS	QA	RM	CC	CR
HSL	3.82	3.82	3.63	3.38	3.41	3.18
VP	3.65	3.78	3.71	3.45	3.46	3.18
VR	3.78	3.76	3.618	3.36	3.51	3.19

Table 11. Average Responses per Community in all MOSE Categories.

	Degrees of Freedom	Sum of Squares	Mean Square	F-Value	P-Value
Community	2	0.0001772	0.0000886	0.02764	0.9728100
Component	5	0.8124472	0.1624894	50.68654	0.0000009
Residuals	10	0.0320577	0.0032058		

Table 12. Analysis of Variance (ANOVA) Table.

With the p-value of 0.9728, at any sensible level of significance we fail to reject H_{0A}, that the various communities showed no real difference between them with respect to their true average pattern of responses over the six survey categories. A boxplot of the data visually depicts the similarities between each community's median values, spread, symmetry and outliers (see Figure 11). This depiction corresponds with the high p-value obtained in the ANOVA and supports the decision of failing to reject H_{0A}.

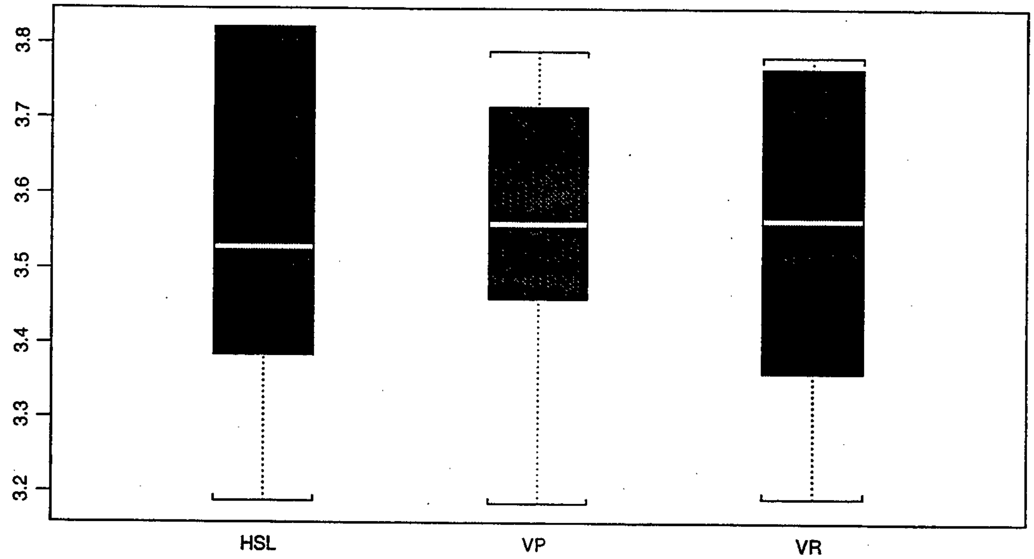

Figure 11. Boxplot of Communities.

The MOSE components, however, proved highly significant with a p-value of 0.0000009. This causes us to reject H_{0B} in favor of the claim that different MOSE categories correspond to different true average responses. A boxplot of the MOSE components is displayed in Figure 12.

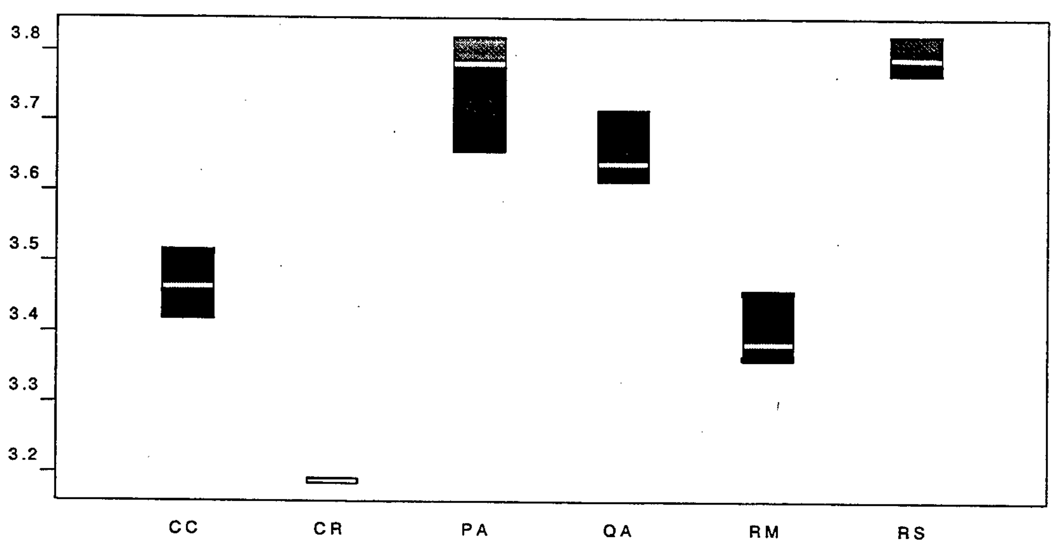

Figure 12. Boxplot of MOSE Components.

There is a noticeable difference between the plots of the MOSE components in Figure 12 compared to the plots by Communities in Figure 11. Especially noticeable is the low average score and low variability of the Communication & Functional Relationship (CR) MOSE component. This graph lends support to the p-value obtained during the ANOVA and the decision to reject H_{0B}.

In rejecting H_{0B}, it is of interest to attempt to determine which levels of factor "B" (or MOSE categories) were different from one another. Tukey's procedure is a method used to determine significant differences between levels of a factor of interest and is described next.

6. Multiple Comparisons in ANOVA

A multiple comparison test utilizing Tukey's Procedure (or "T" method) is conducted to determine which MOSE components proved different from one another. Utilizing the Studentized Range probability distribution, simultaneous confidence intervals for all pairwise comparisons were computed at a selected alpha (α) level. In this case, the pairwise comparing of the means of all six MOSE components resulted in fifteen comparisons. The resulting confidence intervals are intervals for the values of all pairs of differences between true treatment means. Each interval that doesn't include the value of zero yields the conclusion that the treatment means differ significantly (Devore, 1995). Figure 13 provides a graphical representation of the treatment mean confidence intervals.

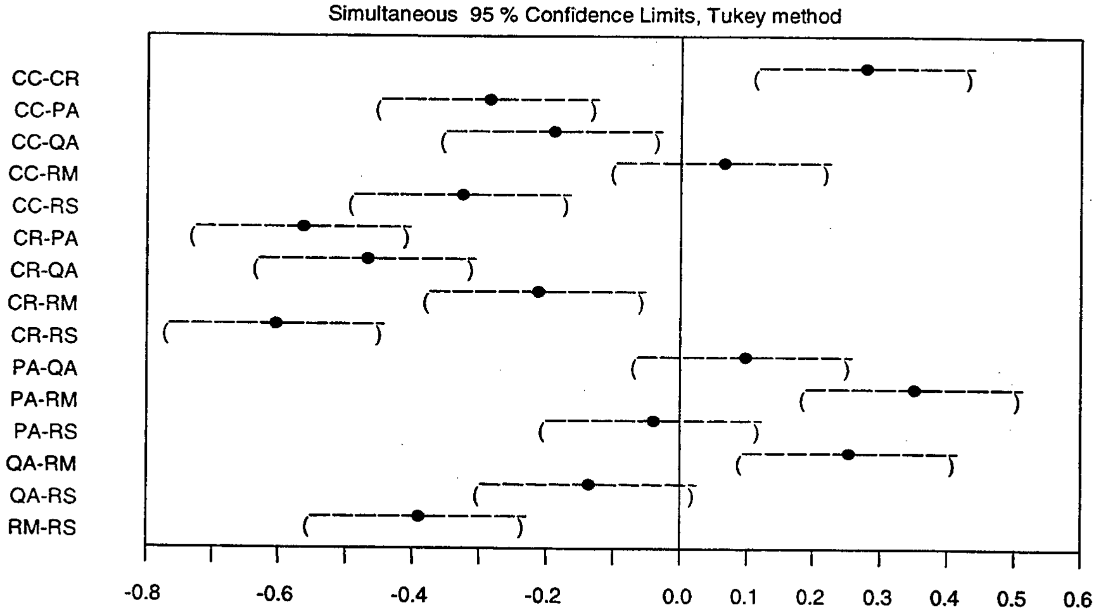

Figure 13. Pairwise Comparisons of MOSE Components Utilizing Tukey's Procedure.

The overall average for each MOSE component is computed and displayed in Table 13. Having the MOSE components arranged in ascending order, the graphical display of the confidence intervals (Figure 13) is used to obtain those pairings that contained the value of zero. Those components are underlined and shown in Figure 14.

MOSE Component	CR	RM	CC	QA	PA	RS
Mean	3.188	3.401	3.466	3.656	3.752	3.792

Table 13. MOSE Components and Associated Means Sorted in Ascending Order.

CR RM CC QA PA RS

Figure 14. Identifying Statistically Different MOSE Components.

Any pair of MOSE components not underscored by the same line corresponded to a pair of true treatment means that were significantly different. Items within the same grouping do not differ significantly.

Figure 14 shows that the MOSE components can be separated into three basic groups. The first group contained the MOSE component of Communication & Relationship (CR) by itself. Via Tukey's procedure, it is judged to be significantly different from all other components and receives the lowest marks. The second group contained the components of Risk Management (RM) and Command & Control (CC). This implies that collectively there was no real difference between the responses received for these two categories. Also implied was that the responses received for these two categories differed from the remaining four MOSE categories. The third group contained Quality Assurance (QA), Process Auditing (PA) and Reward System (RS). These items were collectively similar in response, and receiving the highest marks as a group, were significantly different from either Communication & Relationships (CR) or the group containing Risk Management (RM) and Command & Control (CC).

V. CONCLUSIONS

A. FINDINGS

The results of this thesis conclude that the existing MCAS can be used as a tool for capturing a command's attitude with respect to safety. The statistical methods of Principal Component Analysis and Cluster Analysis fail to identify any single MOSE component that was responsible for controlling the outcome of the survey. Cluster Analysis additionally validate the stability of the survey by achieving similar conclusions through the use of two diametrically functioning algorithms.

Through Analysis of Variance (ANOVA) and multiple comparison testing, it is determined that there is no discernable difference between the aircraft communities surveyed. Though descriptive analysis did discover a few areas of concern that varied between communities, the prevailing attitude is one of a positive outlook with respect to safety within the aviation maintenance organizations surveyed. Those questions having negative responses are individually discussed in Chapter IV and summarized below in Table 14.

	Aircraft Community			
Question	**HSL**	**VP**	**VR**	**Combined**
	Avg	Avg	Avg	Avg
***5**	3.02	2.54	2.82	2.79
9	2.69	2.62	2.77	2.69
22	2.56	3.19	2.61	2.78
23	2.60	2.94	2.78	2.77
24	2.75	3.21	2.88	2.94

Table 14. Questions with Negative Responses.
(* Indicates A Negatively Worded Question).

It is interesting to note that of the five questions listed in Table 13, three of them deal directly with issues concerning either manpower / staffing levels. But despite the varying levels of negativity expressed within these individual questions, the overall means for each MOSE category was in fact positive. Analysis of Variance (ANOVA) and multiple comparison testing also determined that there is a significant difference between the MOSE components with their ability to effect the true average response. It is determined that the six categories could be grouped into three distinct subsets and can provide a reference for any further refining of this survey.

During the exploratory phases of this thesis, a few questions are highlighted as needing restructuring. This is due to the collusion that could result from the addressing of certain areas of safety within the same question. This restructuring results in the addition of five questions to the MCAS for a total count of 40 items. While trying to maintain the number of survey items to a minimum, it is deemed that the clarity obtained in the restructuring (and addition of the five questions) was worth the increase. Appendix F contains the revised 40-items categorized by MOSE component.

B. RECOMMENDATIONS

Intervention strategies should be developed that specifically address each of the questions that are identified as potential problem areas. This will target areas of concern directly, providing a focused effort. Additionally, this thesis can be used as a starting point for numerous future studies. A Marine Corps specific survey could be developed to aid Marine Corps Aviation in assessing its safety posture. Similarities between USMC and USN operating environments (both procedural and operational) would require

minimal modification to the current MCAS to achieve this. If a USMC specific survey is developed, results between Navy and Marine Corps squadrons can be compared and contrasted. Comparisons can also be made between Regular active duty and Reserve units of both services.

Current mishap data for surveyed squadrons could be obtained from the Naval Safety Center. This data could be utilized to compare with patterns developed from the survey results between the Squadron's safety attitude and mishap rate. Finally, other analysis methods could be used to further validate this study and its results.

APPENDIX A. MODEL OF SAFETY EFFECTIVENESS COMPONENTS.

COMPONENT 1: PROCESS AUDITING

1. My command adequately reviews and updates safety practices.
2. The command has a dedicated program that targets individual training deficiencies.
3. My command monitors maintainer qualifications.
4. Support equipment licensing is monitored in this command.
5. Tool control is taken seriously at my command.
6. CDIs/QARs routinely monitor maintenance evolutions.
7. My command uses safety staff to manage personnel at risk.
8. The command uses medical staff to manage occupational hazards and personnel at risk.

COMPONENT 2: REWARD SYSTEM

1. My command recognizes individual safety achievement through rewards and incentives.
2. Unprofessional behavior is not tolerated in the maintenance department.
3. Supervisors encourage reporting safety concerns without fear of retribution.
4. Supervisors discourage violations of SOPs, or NAMP guidelines.
5. My MO/MCPO understands if I feel uncomfortable performing maintenance duties due to personal issues.
6. Violations of SOP, NAMP guidelines, or other procedures are common in my command.
7. Peer influence discourages violations of SOP, NAMP guidelines or other procedures.
8. Personnel are uncomfortable telling supervisors about personal problems including illness.
9. Individuals feel free to report safety violations, unsafe performance, or other unsafe behavior.
10. Our command climate promotes safe maintenance and flight operations.

COMPONENT 3: QUALITY ASSURANCE

1. My command has established standards and maintains quality control.
2. CDIs/QARs are sought after positions in my command.
3. Inspectors perform all required actions before sign off.
4. To meet operational commitments, supervisors allow "cutting corners."
5. Maintainer staffing is sufficient from shift to shift.
6. Proper tools and equipment are available, serviceable and used.
7. Required publications are available, current and used.
8. Maintenance gripes are either corrected or addressed prior to flight.
9. My command has a reputation for quality maintenance.
10. The QA division is respected in my command.
11. Signing off PQS/JQRs/PARs is taken seriously and not gun decked.
12. Maintenance quality on detachments is the same as that in homeport.

COMPONENT 4: RISK MANAGEMENT

1. My command temporarily restricts maintainers who are having personal problems.
2. Based upon my command's current manning and assets, it is over-committed.
3. Supervisors manage hazards associated with maintenance and flight line operations.
4. Supervisors are more concerned with mission completion than aircraft maintenance.
5. My division CPO is aware of individual daily workload requirements.
6. Unsafe conditions are recognized and addressed by M/C, Q/A, or W/C supervisors.
7. Personnel turnover negatively affects my command's ability to operate safely.
8. Day and night check have equal workload and are equally stressful/fatiguing.
9. I am provided adequate resources (time, personnel, and equipment) to accomplish my job.
10. Safety decisions are made at the proper command levels.
11. Safety is part of maintenance planning, and additional training/support is provided as needed.
12. Maintainers are never purposely put in an unsafe situation to meet the flight schedule.

COMPONENT 5: COMMAND AND CONTROL

1. My command ensures all maintainers are responsible and accountable for safe maintenance.
2. My command ensures the uniform enforcement of SOPs among unit maintenance personnel.
3. Supervisors communicate command safety goals, programs, and procedures.
4. Supervisors are actively involved in the safety program and management of safety matters.
5. Supervisors set the example for compliance to established maintenance standards.
6. Supervisors are responsive to unexpected changes and anticipate potential hazards.
7. W/C supervisors are respected by the maintenance chief/officer.
8. All maintenance evolutions are properly supervised by qualified personnel.
9. Maintenance control is effective in managing all maintenance activities.
10. Multiple job assignments and collateral duties adversely affect maintenance.
11. In my command, we believe safety is an integral part of all maintenance and flight line operations.
12. Safety education and training in my command are comprehensive and effective.
13. The safety department is respected by supervisors and maintainers.
14. Maintenance Safety Petty Officer is a sought after billet in my command.

COMPONENT 6: COMMUNICATION / FUNCTIONAL RELATIONSHIPS

1. My command has a problem with passdown between shifts.
2. Within my unit, good communication flow exists up and down the chain of command.
3. Coordination is conducted between the M/C, W/C and QA prior to incorporation of TDs.
4. Work center supervisors, division CPOs and M/C work well together.

5. Aircraft moves are briefed and detailed personnel are qualified.
6. Maintainers are briefed on potential hazards associated with maintenance activities.
7. My supervisor shields me from outside pressures, which may affect my work.
8. QARs are never pressured by the maintenance supervisors to sign off a gripe.
9. Maintenance Control never troubleshoots aircraft discrepancies.
10. QARs are viewed as helpful, and QA is not "feared" in my command.
11. I feel I get all information (internal and external) required to perform my job safely.

APPENDIX B. PROTOTYPE MCAS QUESTIONNAIRE

Purpose: The purpose of this survey is to try and gain valuable insight into the maintenance community's perception concerning aviation mishaps within the Navy and Marine Corps. Your participation and answers will be used as a guide in the Navy's on-going efforts to lower the aviation mishap rate.

The first fifteen questions, part I, regard biographical data; information particular to yourself. This information will aid in the analysis of your responses. NO attempts will be made to identify individual respondents or their organizations.

Part II has 67 questions pertaining to the maintenance community. Please respond to the questions with the answer that most correctly reflects your honest opinion. Using a #2 pencil, completely darken each response.

Thank you in advance for your participation!

PLEASE RESPOND TO EACH ITEM.

1. Your rank? ( ) E-1 - E-3 ( ) E-4 - E-6 ( ) CPO E-7 + ( ) Officer

2. Your community?

VFA	( )	HS	( )	VMFA	( )	VF	( )	HSL	( )
VMA	( )	HC	( )	VP	( )	HCS	( )	VX	( )
VR	( )	VQ	( )	VAQ	( )	VAW	( )		

3. Your designator? (LDO, 152X, etc)? ___________ / NEC _________

4. Are you currently a department head? ( ) Yes ( ) No

5. Your service? ( ) USN ( ) USNR TAR ( ) SELRES ( ) Other

6. Your shift? ( ) DX ( ) NX ( ) MidX ( ) Other, specify_______

7. Total years of service? _________

8. Total years of Aviation Maintenance experience? ________

9. A-School graduate? ( ) Yes ( ) No ( ) N/A

10. Education level: ( ) GED ( ) High School ( ) College, # of years___

11. Unit home location? ( ) East coast ( ) West Coast ( ) Other_________

12. Your rating? ( ) AD/AM ( ) AE/AT ( ) PR/AME ( ) AO ( ) Other _______

13. Your age? ( ) 17-20 ( ) 21-25 ( ) 25-30 ( ) 30+

14. Current maintenance qualifications?
( ) Safe for Flight ( ) QAR
( ) CDI ( ) Supervisor
( ) SPO ( ) N /A

15. Duty: ( ) Shore ( ) Sea

Part II

	1	2	3	4	5
1. My command adequately reviews and updates safety practices.	( )	( )	( )	( )	( )
2. The command has a dedicated program that targets individual training deficiencies.	( )	( )	( )	( )	( )
3. My command monitors maintainer qualifications.	( )	( )	( )	( )	( )
4. Support equipment licensing is monitored in this command.	( )	( )	( )	( )	( )
5. Tool Control is taken seriously at my command.	( )	( )	( )	( )	( )
6. My command recognizes individual safety achievement through rewards and incentives.	( )	( )	( )	( )	( )
7. Unprofessional behavior is not tolerated in the maintenance department.	( )	( )	( )	( )	( )
8. My command has a problem with passdown between shifts.	( )	( )	( )	( )	( )
9. My command follows established standards and maintains quality control.	( )	( )	( )	( )	( )
10. CDIs/QARs are sought after positions in my command.	( )	( )	( )	( )	( )
11. My command temporarily restricts maintainers who are having personal problems.	( )	( )	( )	( )	( )
12. Based upon my command's current manning and assets, it is over-committed.	( )	( )	( )	( )	( )
13. My command ensures all maintainers are responsible and accountable for safe maintenance.	( )	( )	( )	( )	( )
14. My command ensures the uniform enforcement of SOPs among unit maintenance personnel.	( )	( )	( )	( )	( )
15. Within my unit, good communication flow exists up and down the chain of command.	( )	( )	( )	( )	( )
16. Coordination is conducted between M/C , W/C and QA prior to incorporation of TDs.	( )	( )	( )	( )	( )
17. Inspectors perform all required actions before sign off.	( )	( )	( )	( )	( )
18. Supervisors encourage reporting safety concerns without fear of retribution.	( )	( )	( )	( )	( )
19. Supervisors discourage violations of SOPs, or NAMP guidelines.	( )	( )	( )	( )	( )

		1	2	3	4	5
20.	To meet operational commitments, supervisors allow "cutting corners".	( )	( )	( )	( )	( )
21.	Supervisors manage the hazards associated with maintenance and flight line operations.	( )	( )	( )	( )	( )
22.	Supervisors are more concerned with mission completion than aircraft maintenance.	( )	( )	( )	( )	( )
23.	My division CPO is aware of individual daily workload requirements.	( )	( )	( )	( )	( )
24.	Unsafe conditions are recognized and addressed by M/C, Q/A, or W/C supervisors.	( )	( )	( )	( )	( )
25.	Supervisors communicate command safety goals, programs and procedures.	( )	( )	( )	( )	( )
26.	Supervisors are actively involved in the safety program and management of safety matters.	( )	( )	( )	( )	( )
27.	Supervisors set the example for compliance to established maintenance standards.	( )	( )	( )	( )	( )
28.	Supervisors are responsive to unexpected changes and anticipate potential hazards.	( )	( )	( )	( )	( )
29.	W/C supervisors are respected by the maintenance chief/officer.	( )	( )	( )	( )	( )
30.	All maintenance evolutions are properly supervised by qualified personnel.	( )	( )	( )	( )	( )
31.	Work center supervisors , division CPOs and M/C work well together.	( )	( )	( )	( )	( )
32.	Aircraft moves are briefed and detailed personnel are qualified.	( )	( )	( )	( )	( )
33.	Maintainers are briefed on potential hazards associated with maintenance activities.	( )	( )	( )	( )	( )
34.	My supervisor shields me from outside pressures which may affect my work.	( )	( )	( )	( )	( )
35.	QARs are never pressured by the maintenance supervisors to sign off a gripe.	( )	( )	( )	( )	( )
36.	My MO/MCPO understand if I feel uncomfortable performing maintenance due to personal issues.	( )	( )	( )	( )	( )
37.	Maintainer staffing is sufficient from shift to shift.	( )	( )	( )	( )	( )
38.	Maintenance control is effective in managing all maintenance activities.	( )	( )	( )	( )	( )

		1	2	3	4	5
39.	Multiple job assignments and collateral duties adversely affect maintenance.	( )	( )	( )	( )	( )
40.	Personnel turnover negatively affects my command's ability to operate safely.	( )	( )	( )	( )	( )
41.	Violations of SOP, NAMP guidelines, or other procedures are common in my command.	( )	( )	( )	( )	( )
42.	Proper tools and equipment are available, serviceable and used.	( )	( )	( )	( )	( )
43.	Maintenance Control never troubleshoots aircraft discrepancies.	( )	( )	( )	( )	( )
44.	Required publications are available, current, and used.	( )	( )	( )	( )	( )
45.	Maintenance gripes are either corrected or addressed prior to flight.	( )	( )	( )	( )	( )
46.	CDIs/QARs routinely monitor maintenance evolutions.	( )	( )	( )	( )	( )
47.	My command has a reputation for quality maintenance.	( )	( )	( )	( )	( )
48.	The QA division is respected in my command.	( )	( )	( )	( )	( )
49.	Signing off PQS/JQRs/PARs is taken seriously and not gun decked.	( )	( )	( )	( )	( )
50.	Maintenance quality on detachments is the same as that in homeport.	( )	( )	( )	( )	( )
51.	Day and Night Check have equal workload and are equally stressful/fatiguing.	( )	( )	( )	( )	( )
52.	QARs are viewed as helpful, and QA is not "feared" in my command.	( )	( )	( )	( )	( )
53.	Peer influence discourages violations of SOP, NAMP guidelines or other procedures.	( )	( )	( )	( )	( )
54.	Personnel are uncomfortable telling supervisors about personal problems including illness.	( )	( )	( )	( )	( )
55.	I am provided adequate resources (time, personnel and equipment) to accomplish my job.	( )	( )	( )	( )	( )
56.	In my command, we believe safety is an integral part of all maintenance and flight line operations.	( )	( )	( )	( )	( )
57.	I feel I get all information (internal and external) required to perform my job safely.	( )	( )	( )	( )	( )

	1	2	3	4	5
58. Individuals feel free to report safety violations, unsafe performance, or other unsafe behavior.	( )	( )	( )	( )	( )
59. My command uses safety staff to manage personnel at risk.	( )	( )	( )	( )	( )
60. Our command climate promotes safe maintenance and flight operations.	( )	( )	( )	( )	( )
61. Safety decisions are made at the proper command levels.	( )	( )	( )	( )	( )
62. Safety is part of maintenance planning, and additional training/support is provided as needed.	( )	( )	( )	( )	( )
63. Maintainers are never purposely put in an unsafe situation to meet the flight schedule.	( )	( )	( )	( )	( )
64. Safety education and training in my command are comprehensive and effective.	( )	( )	( )	( )	( )
65. The safety department is respected by supervisors and maintainers.	( )	( )	( )	( )	( )
66. Maintenance Safety Petty Officer is a sought after billet in my command.	( )	( )	( )	( )	( )
67. The command uses medical staff to manage occupational hazards and personnel at risk.	( )	( )	( )	( )	( )

APPENDIX C. 35-ITEM MCAS QUESTIONNAIRE

<u>Purpose</u>: The purpose of this survey is to try and gain valuable insight into the maintenance community's perception concerning aviation mishaps within the Navy and Marine Corps. Your participation and answers will be used as a guide in the Navy's on-going efforts to lower the aviation mishap rate.

The first fifteen questions, part I, regard biographical data; information particular to yourself. This information will aid in the analysis of your responses. NO attempts will be made to identify individual respondents or their organizations.

Part II has 35 questions pertaining to the maintenance community. Please respond to the questions with the answer that most correctly reflects your honest opinion. Using a #2 pencil, completely darken each response.

Thank you in advance for your participation!

PLEASE RESPOND TO EACH ITEM.

1. Your rank? ( ) E-1 - E-3 ( )E-4 - E-6 ( )CPO E-7 + ( )Officer

2. Your community?

VFA	( )	HS	( )	VMFA	( )	VF	( )	HSL	( )
VMA	( )	HC	( )	VP	( )	HCS	( )	VX	( )
VR	( )	VQ	( )	VAQ	( )	VAW	( )		

3. Your designator? (LDO, 152X, etc)? ___________ / NEC __________

4. Are you currently a department head? ( ) Yes ( ) No

5. Your service? ( ) USN ( ) USNR TAR ( ) SELRES ( ) Other

6. Your shift? ( ) DX ( ) NX ( ) MidX ( ) Other_______

7. Total years of service? _________

8. Total years of Aviation Maintenance experience? ________

9. A-School graduate? ( ) Yes ( ) No ( ) N/A

10. Education level:( ) GED ( ) High School ( )College, #yrs___

11. Unit home location? ( )East coast ( )West Coast ( )Other

12. Your rating? ( )AD/AM ( ) AE/AT ( )PR/AME ( )AO ( )Other

13. Your age? ( ) 17-20 ( ) 21-25 ( ) 25-30 ( ) 30+

14. Current maintenance qualifications?

    ( )Safe for Flight ( )QAR
    ( ) CDI ( )Supervisor
    ( )SPO ( )N /A

15. Duty: ( ) Shore ( ) Sea

Part II

	1	2	3	4	5
1. My command has a dedicated program that targets individual training deficiencies and ensures the uniform enforcement of SOPs among maintenance personnel.	( )	( )	( )	( )	( )
2. My command monitors maintainer qualifications and support equipment licensing.	( )	( )	( )	( )	( )
3. My command has a reputation for quality maintenance and tool control is taken seriously.	( )	( )	( )	( )	( )
4. Unprofessional behavior is not tolerated in the maintenance department.	( )	( )	( )	( )	( )
5. My command has a problem with passdown between shifts.	( )	( )	( )	( )	( )
6. My command adequately reviews and updates safety practices, follows established standards and maintains quality control, ensuring that all maintainers are responsible and accountable for safe maintenance.	( )	( )	( )	( )	( )
7. QARs/ CDIs and Maintenance Safety Petty Officer are sought after billets in my command.	( )	( )	( )	( )	( )
8 . Medical and safety staff are used to help identify, manage, and temporarily restrict personnel with personal issues and those who pose a risk to safe maintenance in this command.	( )	( )	( )	( )	( )
9. Based upon my command's current manning and assets, it is not over-committed.	( )	( )	( )	( )	( )
10. Within my unit, good communication flow exists up and down the chain of command.	( )	( )	( )	( )	( )
11. Maintenance control is effective in managing all maintenance activities, coordinating between M/C, W/C, and QA prior to the incorporations of TDs.	( )	( )	( )	( )	( )
12. Inspectors perform all required actions before sign off.	( )	( )	( )	( )	( )
13. Safety concerns or unsafe hazards associated with maintenance/flight line operations can be reported without fear of retribution knowing that the W/C, Q/A, or M/C supervisors will address and manage them for proper corrections.	( )	( )	( )	( )	( )
14. Violations of SOP, NAMP guidelines or other procedures are discouraged in this command.	( )	( )	( )	( )	( )

	1	2	3	4	5
15. Supervisors are more concerned with proper aircraft maintenance than mission completion and do not allow cutting corners to meet operational commitments.	( )	( )	( )	( )	( )
16. My supervisors are aware of individual daily workload requirements and recognize safety achievements through rewards and incentives.	( )	( )	( )	( )	( )
17. Supervisors communicate command safety goals, programs and procedures.	( )	( )	( )	( )	( )
18. W/C supervisors are respected by the maintenance chief/officer.	( )	( )	( )	( )	( )
19. Qualified personnel properly supervise all maintenance evolutions and maintainers are briefed on the potential hazards associated with maintenance activities.	( )	( )	( )	( )	( )
20. My supervisor shields me from outside pressures which may affect my work.	( )	( )	( )	( )	( )
21. QARs are never pressured by the maintenance supervisors to sign off a gripe.	( )	( )	( )	( )	( )
22. Maintainer staffing is sufficient, is equally worked and is equally stressed / fatigued from shift to shift.	( )	( )	( )	( )	( )
23. Multiple job assignments and collateral duties do not adversely affect maintenance.	( )	( )	( )	( )	( )
24. Personnel turnover does not affect my command's ability to operate safely.	( )	( )	( )	( )	( )
25. Violations of SOP, NAMP guidelines, or other procedures are not common in my command.	( )	( )	( )	( )	( )
26. Proper tools and equipment are available, serviceable and used and I am provided adequate resources (time, personnel) to accomplish my job.	( )	( )	( )	( )	( )
27. Maintenance Control never troubleshoots aircraft discrepancies.	( )	( )	( )	( )	( )
28. Required publications are available, current, and used.	( )	( )	( )	( )	( )
29. The QA division is respected and CDIs / QARs routinely monitor maintenance evolutions ensuring that maintenance gripes are either corrected or addressed prior to flight.	( )	( )	( )	( )	( )
30. Signing off PQS/JQRs/PARs is taken seriously, not gun decked and maintenance quality is as high on detachments as it is in homeport.	( )	( )	( )	( )	( )

	1	2	3	4	5
31. Safety is an integral part of this command's maintenance planning/flight line operations, where QARs are helpful and the QA division is not "feared".	( )	( )	( )	( )	( )
32. Personnel are comfortable telling supervisors about personal problems including illness.	( )	( )	( )	( )	( )
33. I feel I get all information (internal and external) required to perform my job safely, and feel free to report safety violations, unsafe performance or other unsafe behavior.	( )	( )	( )	( )	( )
34. Maintainers are never purposely put in an unsafe situation to meet the flight schedule.	( )	( )	( )	( )	( )
35 Safety education and training in my command are comprehensive and effective and the safety department is respected by the supervisors and maintainers.	( )	( )	( )	( )	( )

APPENDIX D. MOSE MAPPING INDEX

Purpose: The purpose of this Appendix is to display a cross-reference of the questions from the 67-item Proto-type survey that composed the 35-item Final MCAS questions.

Final MCAS Question #	Proto-Type MCAS Question # (s)
1	2, 14
2	3, 4
3	5, 47
4	7
5	8
6	1, 9, 13
7	10, 66
8	11, 36, 67
9	12
10	15
11	16, 38
12	17
13	18, 21, 24
14	19, 53
15	20, 22
16	6, 23
17	25
18	29
19	30, 33
20	34
21	35
22	37, 51
23	39
24	40
25	41
26	42, 55
27	43
28	44
29	45, 46, 48
30	49, 50
31	52, 56, 62
32	54
33	57, 58
34	63
35	64, 65

APPENDIX E. MOSE COMPONENT DISTRIBUTIONS.

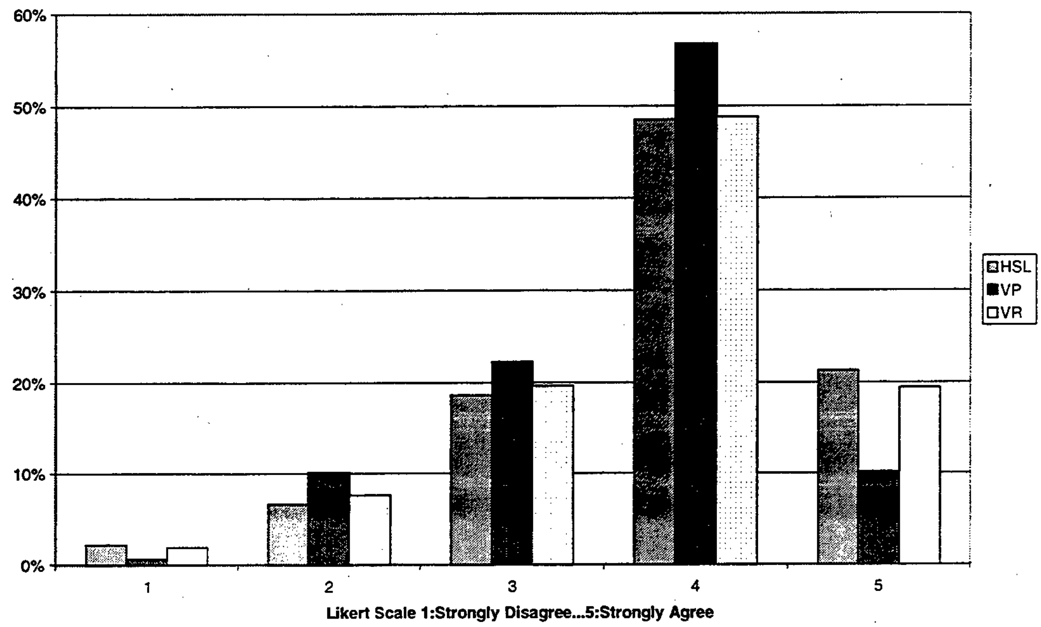

Figure 15. Process Auditing MOSE by Community.

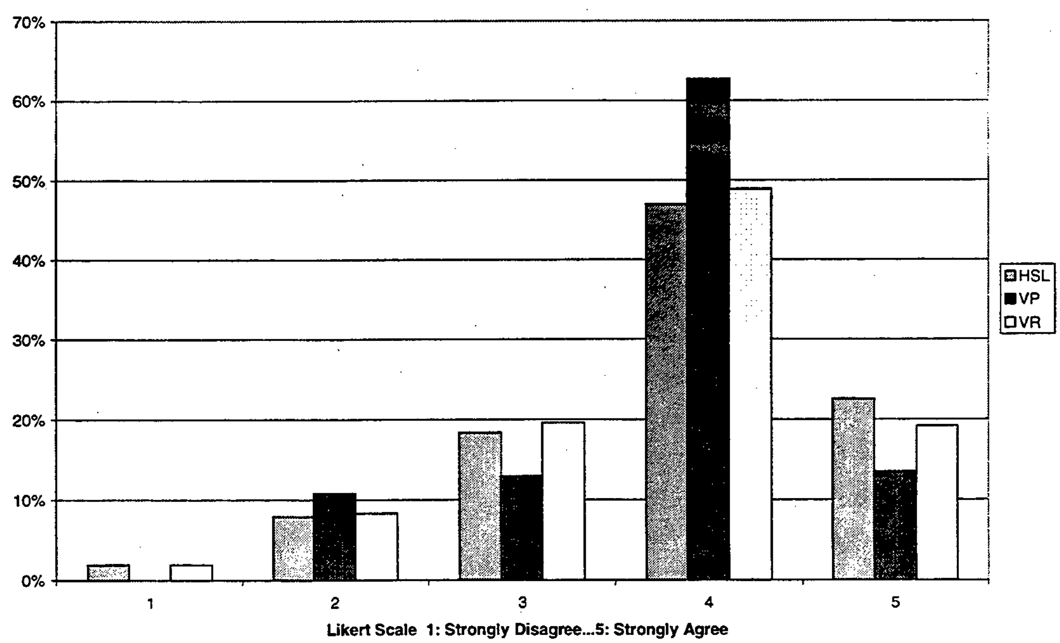

Figure 16. Reward System MOSE by Community.

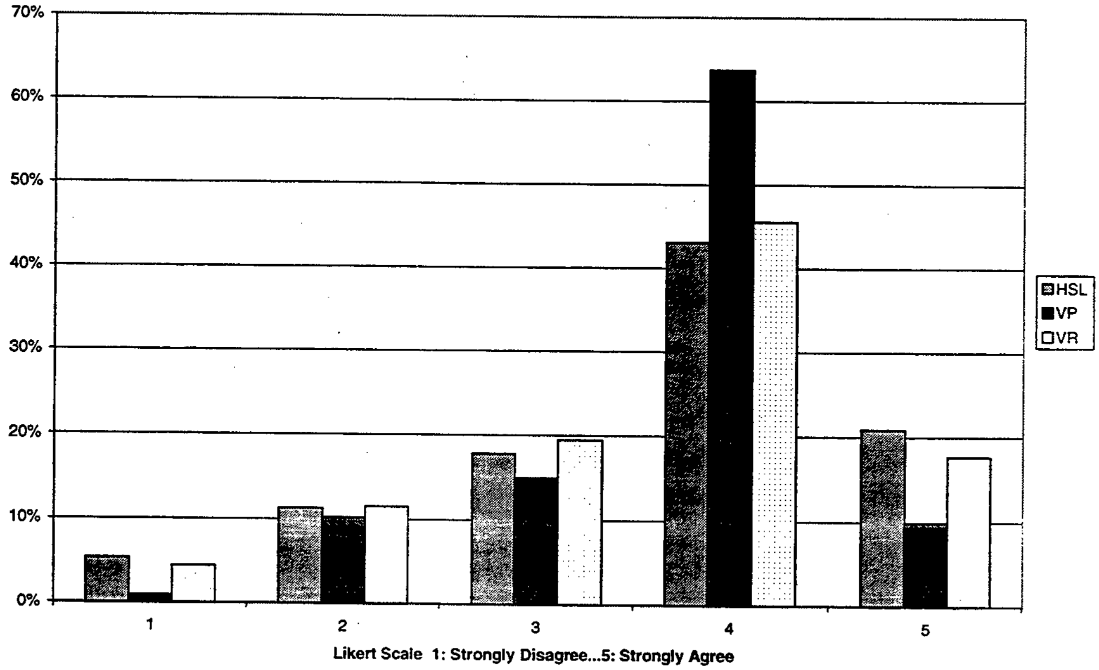

Figure 17. Quality Assurance MOSE by Community.

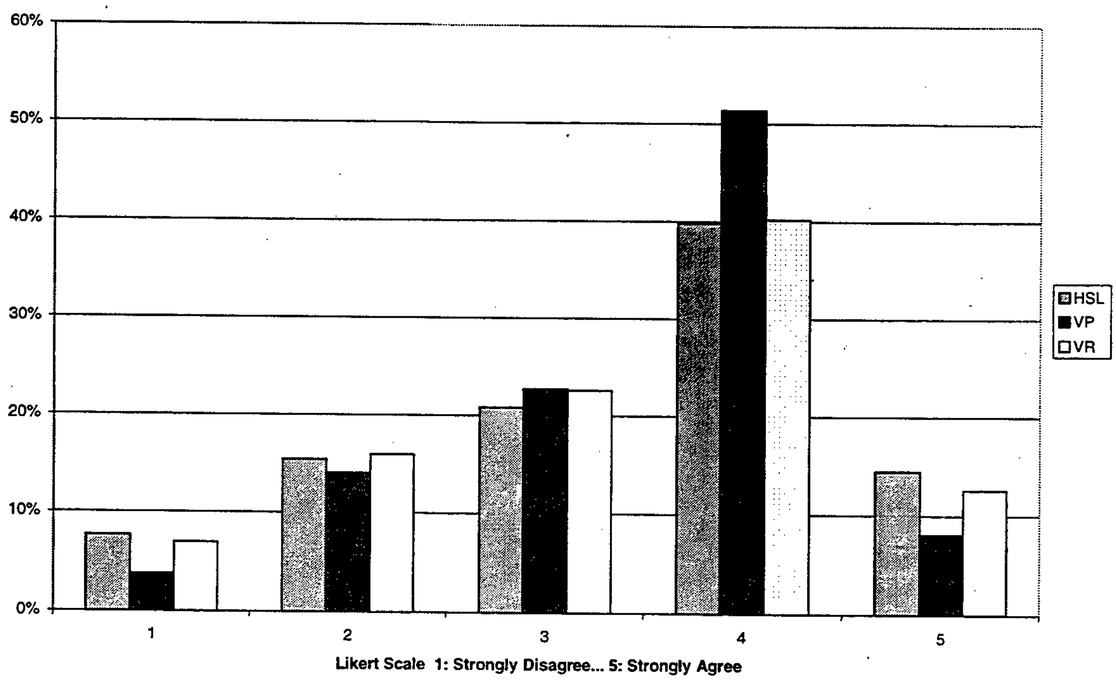

Figure 18. Risk Management MOSE by Community.

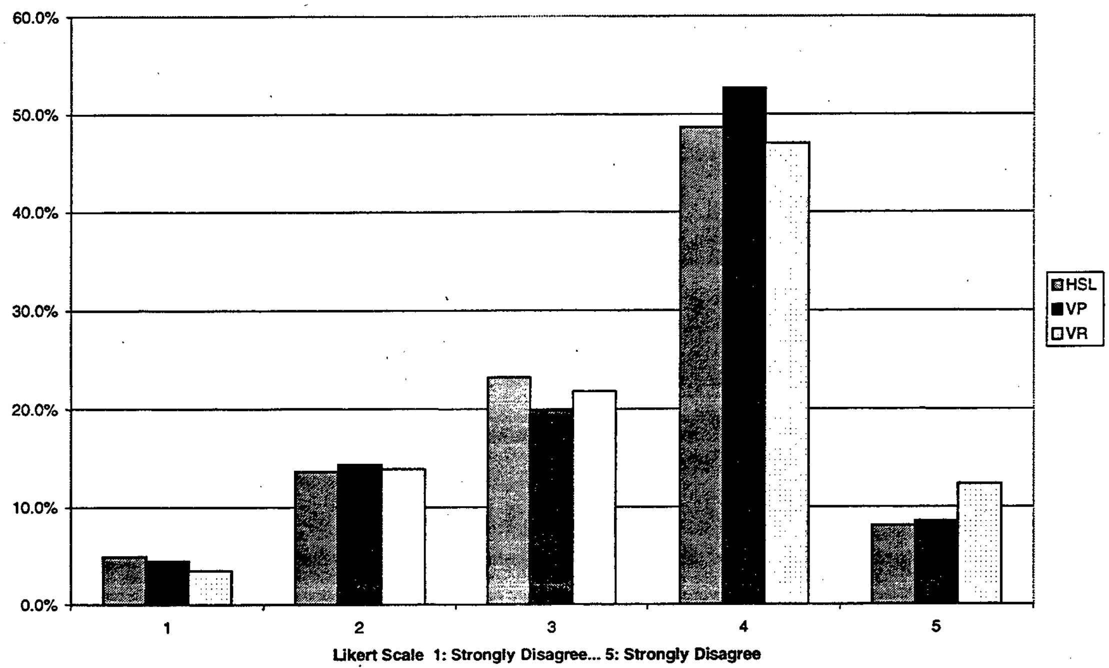

Figure 19. Command & Control MOSE by Community.

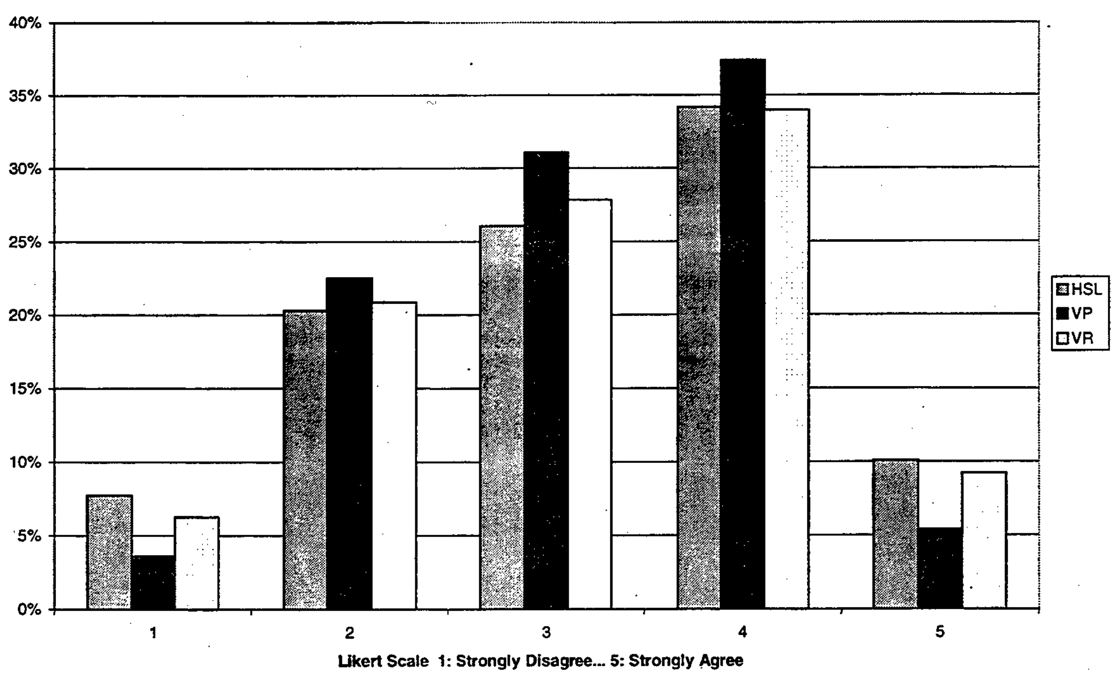

Figure 20. Communication & Functional Relationships MOSE by Community.

APPENDIX F. 40-ITEM MCAS QUESTIONNAIRE.

The items for the 40 Question MCAS are listed according to MOSE Component.

COMPONENT 1: PROCESS AUDITING

1. The command adequately reviews and updates safety practices.
2. The command monitors maintainer qualifications and has a program that targets training deficiencies.
3. The command uses safety and medical staff to identify/manage personnel at risk.
4. CDIs/QARs routinely monitor maintenance evolutions.
5. Tool Control is taken seriously in the command and support equipment licensing is closely monitored.
6. Signing of PQS/JQRs/PARs is taken seriously and not gundecked.

COMPONENT 2: REWARD SYSTEM and SAFETY CLIMATE

1. Our command climate promotes safe maintenance and flight operations.
2. Supervisors discourage SOP, NAMP guideline, or other procedure violations and encourage reporting safety concerns without fear of retribution.
3. Peer influence discourages SOP, NAMP guideline, or other procedure violations and individuals feel free to report safety violations, unsafe performance, or unsafe behaviors.
4. Violations of SOP, NAMP guidelines, or other procedures are not common and unprofessional behavior is not tolerated in the command.
5. The command recognizes individual safety achievement through rewards and incentives.
6. Personnel are comfortable approaching supervisors about personal issues/illness.
7. Maintenance Safety Petty Officer, Quality Assurance Representative, and Collateral Duty Inspector are sought after billets in the command.

COMPONENT 3: QUALITY ASSURANCE

1. The command has a reputation for quality maintenance and has set standards to maintain quality control.
2. The QA Division and Safety Department are respected in the command and are seen as essential to mission accomplishment.
3. QARs/CDIs perform all required actions before sign-off and are never pressured by maintenance supervisors.
4. Maintenance quality on detachments is the same as that at home station.
5. Required publications/tools/equipment are available, current/serviceable, and used.
6. QARs are viewed as helpful, and QA is not “feared” in my command.

COMPONENT 4: RISK MANAGEMENT

1. Multiple job assignments and collateral duties adversely affect maintenance.
2. Safety is part of maintenance planning, and additional training/support is provided as needed.
3. Supervisors recognize unsafe conditions and manage the hazards associated with maintenance and flight line operations.
4. I am provided adequate resources (time, personnel and equipment) to accomplish my job.
5. Personnel turnover does not negatively affects the commands ability to operate safely and based upon my its current manning/assets, it is not over-committed.
6. Supervisors are more concerned with aircraft maintenance than mission completion, and do not permit cutting corners or purposely putting maintainers in unsafe situations to meet the flight schedule.
7. Maintainer staffing is sufficient from shift to shift, and Day/Night Check have equal an equally stressful/fatiguing workload.
8. Supervisors shield personnel from outside pressures that may affect their work, and are aware of individual workload and personal issues.

COMPONENT 5: COMMAND AND CONTROL

1. The command temporarily restricts maintainers who are having personal problems.
2. Safety decisions are made at the proper command levels, and CC W/C supervisors are respected by the maintenance chief/officer.
3. Supervisors communicate command safety goals, programs, and procedures, and are actively involved in the safety program and management of safety matters.
4. Supervisors set the example for compliance to maintenance standards and ensure uniform enforcement of SOPs, NAMP guidelines, and other procedures among maintenance personnel.
5. In my command, safety is an integral part of all maintenance and flight line operations and all maintainers are responsible and accountable for safe maintenance.
6. Safety education and training in my command are comprehensive and effective.
7. All maintenance evolutions are properly briefed, supervised, and staffed by qualified personnel, including flight line activities such as aircraft moves.
8. Maintenance control is effective in managing all maintenance activities.

COMPONENT 6: COMMUNICATION / FUNCTIONAL RELATIONSHIP

1. Good communication flow exists up and down the chain of command and I get all the information required to perform my job safely.
2. Work center supervisors, division CPOs, QA, and M/C coordinate their actions, including the incorporation of TDs.
3. My command has effective pass-down between shifts.
4. Maintenance Control always troubleshoots aircraft discrepancies and gripes are either corrected or addressed prior to flight.
5. Maintainers are briefed on potential hazards associated with maintenance activities.

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